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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1923.

GENERAL PHYSICS.

1499. *Determining the Density of Water Saturated with Air.* **O. E. Frivold.** (Phys. Zeits. 24. pp. 86–87, Feb. 15, 1923.)—An addition to previous paper [Abstract 346 (1921)], mainly a discussion of the systematic errors that may affect the observations. H. B.

1500. *A New Specific Gravity Apparatus for Natural Gas.* **T. R. Weymouth, R. P. Anderson,** and **J. R. Fay.** (Indust. and Eng. Chem. 15. pp. 358–359, April, 1923.)—An apparatus suitable for determining in the field the specific gravities of gases, and comprising an orifice and a capillary tube in series, is described. The rate of flow of gas through the orifice is kept constant by maintaining a constant differential pressure between the ends of the capillary tube, and the specific gravity of the gas is then read from a scale calibrated in terms of the differential pressure produced at the orifice. J. S. G. T.

1501. *New Precision Hydrometer.* **C. W. Foulk.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 327–334, April, 1923.)—The principle is that of submerged floating equilibrium with a chain hung in a catenary curve between the float and an independent point of support. The float can move freely along a tube which is open at both ends and has a suitable scale marked on it. The advantages of such an arrangement are: (1) Greatly increased sensitiveness of the float to changes in density of the liquid; (2) changes in density of the liquid, however small, cause proportional changes in the position of the float; (3) the catenary hanging of the chain prevents tangling; (4) the apparatus is easily handled. The effect of the various constants of such a balanced float on its response to differences of density of the liquid is given with close approximation by the equation $\Delta d = \frac{(D - d) \times \Delta b}{2D \times V} \times w$, where Δd = density change in liquid which causes a vertical displacement of float of Δb, measured in cm.; D = density of material of chain; d = density of liquid; V = volume of float measured in c.c.; and w = weight in grammes of 1 cm. of chain. It will be seen that the sensitiveness of the instrument is proportional to the volume of the float and inversely

proportional to the weight of unit length of the chain. The author describes various modifications of the instrument. T. C. H.

1502. *Scientific Notation.* **F. F. Martens.** (Elekt. Zeits. 44. pp. 520–522, May 31, 1923.)—This is an attempt to systematise scientific notation, in so far as physical investigations are concerned. W. H. S.

1503. *Bibliography of Petroleum and Allied Substances in* 1919 *and* 1920. **E. H. Burroughs.** (Bureau of Mines, Bull. 216. [374 pp.] Washington, 1923.)

1504. *Improvement in the Sprengel Pump.* **J. J. Manley.** (Phys. Soc., Proc. 35. pp. 137–139, April, 1923.)—The paper relates to a further improvement in the pump recently described [Abstract 1467 (1922)], which is designed to avoid irregularities due to air skins on the inner surfaces of the apparatus. The present improvement consists in means for providing a mercury seal during periods when the pump is out of use, whereby the formation of fresh air skins is prevented. AUTHOR.

1505. *Progressive Waves of a Permanent Oscillatory Type in Liquids (Second Approximation).* **U. Crudeli.** (N. Cimento, 25. pp. 43–62, Jan.–Feb., 1923.)—This is a purely mathematical paper. A. E. G.

1506. *Boundary Lubrication in Engineering Practice.* **T. E. Stanton.** (Engineer, 135. pp. 678–680, June 29, 1923.)—Refers to the difference between the state of lubrication between cylindrical surfaces with arcs of contact as small as 14 deg. at pressures up to 3·5 tons per sq. in., and that of the state existing in worm gears in which the lubrication is known, from the N.P.L. experiments in 1921, to depend upon characteristics other than viscosity and the nature of the two surfaces. The author describes the apparatus made to imitate the conditions existing in worm gears and gives results of experiments in damping the swings of the pendulum with various lubricants. The experiments show that by this comparatively simple apparatus the characteristics of lubricants and bearing metals under the conditions of boundary lubrications in practice can be investigated rapidly and conveniently.
W. N. Y. K.

1507. *Sensitivity of Hot-Wire Inclinometer in Air and in Carbon Dioxide.* **J. S. G. Thomas.** (Phil. Mag. 45. pp. 945–957, May, 1923.)—Two series of experiments were carried out, one with a large brass cylinder or chamber and the other with a small one, the inclinometer being composed of two fine heated platinum wires 0·10 mm. diameter. Particulars of the two wires, which constitute two arms of a Wheatstone bridge, and the method of mounting in the brass chamber are given. The deflection of the galvanometer depends upon the variation of the thermal conditions of the respective wires as the plane of the wires is rotated about a horizontal axis either in or at right angles to their plane. At atmospheric pressure (760 mm.) for equal values of the bridge current there is a relatively small difference in the deflection for 90° rotation. Curves were plotted of the results of the experiments, and it was observed that for all the respective values of the bridge current, provided the pressure in the chamber is sufficiently reduced, the sensitivity of the

inclinometer is greater in carbon dioxide than in air. In the large chamber the differential thermal effect experienced by the wires on rotation is conditioned partly by convection and partly by conduction and radiation; in the small chamber convection effects are almost eliminated. The differential convection effect is influenced by (*a*) the higher temperature of the wire, (*b*) the diminished density of the gas in the large chamber, and (*c*) the increased velocity of the free convection current from the wires due to (*a*) and (*b*). An explanation of the characteristics of the various curves is given. For large values of the heating current and moderate or large values of the pressure in the chamber the sensitivity of the inclinometer in which the wires are surrounded by air would be greater than in the case where carbon dioxide surrounds the wires. Results are also given in the two cases when only a single wire is used. [See Abstract 188 (1921).] T. C. H.

1508. *Diffusion in an Electric Field.* **S. Sano.** (Phys. Math. Soc. Japan, Proc. 5. pp. 3–5, Jan., 1923. In English.)—The paper is a supplement to a former one [Abstract 649 (1906)], and is mainly concerned with the discussion of difficulties suggesting emendations and limitations in the author's theory as originally propounded. G. W. DE T.

1509. *New MacMichael Viscosimeter.* **W. H. Herschel.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 335–353, April, 1923.)—This instrument consists essentially of a torsional pendulum with a bob hanging in the liquid to be tested. On a turntable is placed an outer cup concentric with the cup holding the liquid; the space between the cups containing water or oil and a coil of resistance wire for electric heating. As the turntable is rotated at a constant speed by an electric motor, the pendulum has a constant deflection during any one test, due to the viscous drag of the liquid. When a cylindrical bob is used instead of the disc type, a third cup is placed inside the other two, oil or water being poured round it to complete contact with the heating jacket. Methods of avoiding sources of error such as end effects, turbulence, and imperfect elasticity of the torsional wire are described. The author goes into the measurement of moments. A series of experimental results are given, using wires of different diameters with a cylindrical bob, and the constants of wires obtained by calibration with oils of known viscosity are tabulated. In the measurement of deflection by the mirror and straight scale there are two cases: (1) Where the deflection is very small, (2) where the angle is too large to assume that it is proportional to its tangent. Both of these are fully discussed by the author. T. C. H.

1510. *Measurement of Air Flow.* **R. O. King.** (Engineering, 115. pp. 456–458, April 13, and pp. 481–482, April 20, 1923.)—An account of the methods in use in the engine testing laboratories of the Imperial College of Science for measuring the rate of supply of air to petrol engines. The measuring device is a sharp-edged circular orifice ("throttle-plate") in the side of a box connected to the induction pipe, the pressure head across the orifice being measured by a manometer, one limb of the tube being connected to the box and the other open to the atmosphere. Tables giving the weight of dry air passing per second for orifices from $\frac{3}{8}$ in. to $2\frac{1}{8}$ in., for a head of 1 in. of water, at standard tem-

perature and pressure, and the corrections to be applied at other temperatures and pressures are used; for other heads, flow $\propto \sqrt{\text{head}}$. A numerical example explains how they are employed. The inaccuracies due to variable suction are avoided by air-boxes between orifice and induction pipe. It is found that two in series are more effective than is a single larger box. Emphasis is laid on the absolute necessity of stopping all leaks if results are to be at all trustworthy. An ingenious device, due to Prof. Callendar, consisting of a $\frac{1}{8}$-in. orifice in a by-pass around a shut-off valve, at the same time detects and measures leakage. For the minutiæ of the method, the paper must be consulted.

W. G. B.

1511. *Effect of Pulsations on the Flow of Gases.* **H. Judd** and **D. B. Pheley.** (Am. Soc. Mech. Eng., J. 45. pp. 223–228; Disc., 228–229, and 270, April, 1923.)—An investigation of the errors occurring in the measurement of gas flow, due to its pulsation and of means of eliminating these errors. A small reciprocating compressor, discharging into a 3-in. pipe line 70 ft. long, was used as the source of pulsating flow, and "inferential" meters only were studied. While the results obtained refer, strictly, to the actual system used, yet it is probable that the basic principles established will be of universal application.

There is pulsation of velocity, and of pressure. The former was studied by means of a Pitot tube, the impact and trailing orifices being connected to opposite sides of a diaphragm to which a mirror was fixed, allowing photographic records of the pulsations to be obtained. Some of these records are given, and this apparatus formed a means of testing the devices tried as to their efficacy in destroying the pulses. The pressure pulses were detected by Crosby indicators attached to two points of the tube. One result of the examination of simultaneous diagrams was to show that these pressure pulses were transmitted at the velocity of sound. The most significant feature of the meter readings was an increase in the case of pulsating flow, amounting to, in extreme cases, several hundred per cent. Throttling the manometer steadied it, but did not reduce the error. Throttling the tube itself was of some use, but even when this introduced a pressure drop of 6 in. of mercury, there was still an error of about 3 %. The most effective device was a combination of throttling with an expansion chamber. W. G. B.

1512. *Influence of an Electric Field on the Viscosity of a Gas.* **H. Sirk.** (Zeits. f. Physik, 13. 1 and 2. pp. 35–47, 1923.)—On the kinetic theory of gases, viscosity is considered as depending upon pressure and temperature. The author considers its dependence on an electric field assuming that the molecules are neutral aggregates of positive and negative electricity. It is assumed that the molecules are electric "quadrupoles," which in an electric field F have a moment $m = \alpha F$. The factor α, which represents the polarisability of the molecule, is given by $\alpha = 3\,P_0/4\pi N$, which is obtained from the molecular refraction of the material for infinitely long waves P_0. N is the Loschmidt constant. [See Lorentz, "The Theory of Electrons," S. 303, Note 54, Debye, Abstract 571 (1912).] The potential of a quadrupole is given in terms of C_1, C_2, C_3, the principal electric moments of inertia of the molecule. To fix our ideas, consider the gas to flow through a narrow parallelepiped space, the layers of equal velocity being planes. Let v be the velocity of

a molecule in a direction, making an angle θ with the normal to these planes. The viscosity can then be written $\eta = \int_0^{\pi} [K'\sqrt{T} \cos^2\theta \sin\theta \, . \, d\theta/S^2]$ where S is the smallest distance between two molecules without impact. If there is no force between the molecules, this is equal to the molecular diameter S, and the expression is the classical one. If there are attractive forces between the molecules, then Sutherland gives $S^2 = s^2 (1 + cH/KT)$ where H denotes the work done by two molecules in moving from infinity up to contact; K is Boltzmann's constant, and c a factor depending on the power law evaluated by Enskog (Dissertation, Upsala, 1917). If there is no electric field, H is independent of direction, and if we put $cH/K = \phi$ = Sutherland's constant, we find $\eta \propto \sqrt{T}/(1 + \phi/T)$, which gives good agreement with experiment for the dependence of η on the temperature.

It is now assumed that an electric field F acts on the gas in a direction normal to the flow. H now becomes a function of ϕ which the author proceeds to evaluate by the help of Debye's work and the property of dipoles, and finally obtains an equation $H = AB/4 - AC + D + AB \cos^2\theta/4$. To calculate ηF, the viscosity with the field on, we have to calculate the value of $1 + cH/KT$. Making use of Enskog's values for c, the author finally obtains $\eta F/\eta_0 = 1 - (F^2 c 4\alpha^2/KS^3)(2/5\, B - C)/(T + \phi)$. Whether this ratio is $\gtrless 1$ depends only on B and C, as all the other quantities are positive. The expressions obtained for B and C show that $(2/5\, B - C)$ is also positive, and hence the electric field diminishes the viscosity. A numerical calculation for the cases of nitrogen and oxygen gives respectively the expressions $\eta F/\eta_0 = 1 - 4{\cdot}1 \times 10^{-9}$, and $\eta F/\eta_0 = 1 - 3{\cdot}0 \times 10^{-9}$ at 14° C. These results agree well with the experimental values obtained by S. Ray. [Abstract 2185 (1922).] T. B.

1513. *Contraction of Photographic Gelatine Films.* **C. Davidson.** (Optical Soc., Trans. 24. 1. pp. 41–44; Disc., 44–46, 1922–1923.)—The residual errors of a series of parallax plates are tabulated, and it is shown that the probable error due to film displacement is $\pm$ 0·0003 mm., confirming Schlesinger's results. Ross has shown that on plates developed with a tanning compound there is a general contraction towards small developed images. The author interprets these results as due to unequal drying. The image gelatine, having been tanned by the developer, contains less water than the surrounding film and hence dries quicker and contracts at the expense of the wet portions round the image. Uneven drying shows exactly a similar action. *Discussion.*—**F. Dyson:** Care is always taken in drying stellar photographs for measurement. **T. Y. Baker:** The contraction in celluloid films is far more serious. **R. W. Cheshire:** The final overall contraction of a celluloid coated film is about 1 %. Local distortions do not exceed 6 μ, and can be eliminated by subsequent washing. **B. V. Storr:** The irregularity in the film is probably due to initial stresses in the celluloid. A. Wh.

1514. *Elastic Constants of Spruce.* **H. Carrington.** (Phil. Mag. 45. pp. 1055–1057, May, 1923.)—A table giving the results of experiments on four balks of spruce, A, B, C, D, shows the mean values of the moduli in terms of a unit stress of 10^4 grammes weight per sq. cm. The direct moduli are noted by E_x, E_y, E_z. F_x, F_y, F_z are equal respectively

to three relations of the type $F_x = E_y/\sigma_{yz} = E/_z\sigma_{zy}$ where σ_{yz} . . . denotes $\frac{\text{lateral strain in the direction of } z}{\text{logitudinal strain in the direction of } y}$. The axis of z is in the direction of the grain, while x and y are in directions perpendicular to the grain and normal and tangential respectively to the annual layers. μ_{yz}, μ_{zx}, μ_{xy} are the three principal values of the moduli of rigidity. The table of elastic constants results is as under :

Balk.	A.	B.	C.	F.	G.	H.	L.	M.	N.
A	984	550	11,000	369	564	388	621	506	22·65
B	1,100	863	18,150	606	589	437	860	637	38·1
C	1,015	607	12,650	424	608	495	632	506	23·6
D	1,005	500	11,000	385	579	396	602	588	26·1

Values of A, B, and C are given by three equations of the type

$$A = \frac{1/E_yE_z - 1/F_x^2}{\Delta}$$

and values of F, G, and H by three equations of the type

$$F = \frac{1/E_xF_x + F_y1/F_z}{\Delta}$$

$$\text{where } \Delta = \begin{vmatrix} 1/E_x & -1/F_z & -1/F_y \\ -1/F_z & 1/E_y & -1/F_x \\ -1/F_y & -1/F_x & 1/E_z \end{vmatrix}$$

whilst L, M, and N are equal respectively to M_{yz}, M_{zx}, M_{xy}. [See Abstract 1476 (1922).] T. C. H.

1515. *Theory of Rowing.* **F. H. Alexander.** (Durham Univ. Phil. Soc., Proc. 6. Part 3. pp. 160–179, 1922.)—The author explains the mechanical principles concerned in the propulsion of a "racing eight." Graphs are given showing calculated values of speeds of the oarsmen's bodies, and of the boat; and also of the forces employed. These are based on estimated values of fluid resistance, and of pressure on the oar blades. The results of some French and English experiments, in automatically recording speeds and forces, are given for comparison with the results of the author's calculations. AUTHOR.

1516. *Precession of the Spinning Top.* **G. Greenhill.** (Phil. Mag. 45. pp. 385–399, March, 1923.)—Some corrections to a former paper [Abstract 2373 (1922)]. It is pointed out that the dynamics of the top, spinning about a fixed point O, may be stated in the two propositions: (1) The impulse vector OH describes a curve, in a horizontal plane in consequence of the constancy of the component impulse about the vertical; and the projection of the centre of gravity of the top on this horizontal plane describes the hodograph of the curve traced by H, turned back through a right angle. This is true universally of any unsymmetrical top. For

a top with uniaxial symmetry, the curve traced by H is a Poinsot herpolhode, and the angular velocity about the axle is constant. The latter motion is expressible by an elliptic function; but, so far, for the general unsymmetrical top, the determination of the H curve has defied analysis. Four plates of curves accompany the paper. G. W. DE T.

1517. *The Rupture Constant of Rock-Salt.* **F. Zwicky.** (Phys. Zeits. 24. pp. 131–137, March 15, 1923.)—Polányi showed [see Abs. 1044 (1922)] by a rough calculation that it was probable that the rupture constant for rock-salt according to the ion theory is about 100 to 1000 times greater than that found by experiment. In consequence this result was confirmed by more accurate direct calculation. A solution of the discrepancy appears possible by taking into consideration movements due to temperature. The present paper which is a purely mathematical one deals with this aspect of the question. A. E. G.

1518. *Stability of a Viscous Liquid contained between Two Rotating Cylinders.* **G. I. Taylor.** (Roy. Soc., Phil. Trans. 223. pp. 289–343, Feb. 8, 1923.)—A further addition to the growing list of the author's

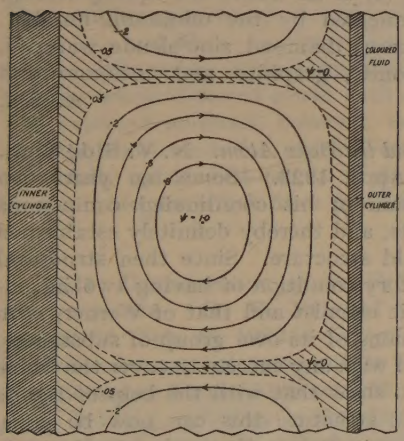


FIG. 1.—Stream lines of motion after instability has set in, μ positive.

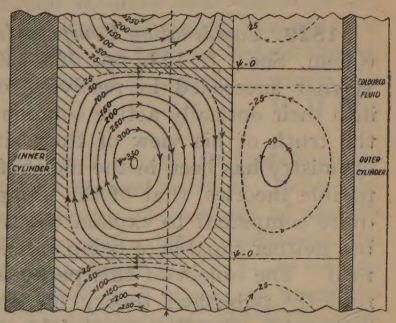


FIG. 2.—Stream lines of motion after instability has set in, $\mu = -1{\cdot}5$.

correlated mathematical and experimental study of special cases of fluid motion [see Abstract 715 (1922), 261 (1923)]. After a review of previous work by others, the mathematical investigation of a possible symmetrical disturbance in the motion of a viscous fluid contained between two infinite coaxial rotating cylinders is undertaken; for details the paper must be consulted. The criterion of stability is obtained, but its discussion is confined to the search for the type of instability which first appears as the speed of rotation is gradually increased, which is probably the only one that can be put to the test of experiment. This is found to be a splitting up into sections by equidistant planes perpendicular to the axis, each such section containing one or two vortex rings, according as the cylinders rotate in the same or opposite directions, and the sense of vortex rotation in two adjacent sections is opposite (see the stream-lines sketched.) This type of instability was experimentally realised,

and detected by introducing coloured water through a ring of holes in the inner cylinder. Comparison between observed and predicted spacing of the vortices, and the speed at which instability set in was extremely good, observed and predicted points falling close to smooth curves. In many cases a spiral form of instability was observed. The subsequent motion of the fluid was observed, but no effort was made to circulate it. If the speed was slightly increased, the vortex system remained (one is photographed after a " life " of 8 minutes) provided the directions of rotation were the same. For rotations in opposite direction, the system ultimately broke up, alternate vortices expanding on one side of the cylinder and contracting on the other, the intermediate ones expanding and contracting to fill up the spaces left. Eight photographs of the vortices are given. W. G. B.

1519. *Cleavage and Structure of Crystals.* **M. L. Huggins.** (Am. J. Sci. 5. pp. 303–313, April, 1923.)—The author shows that cleavage is governed by three simple rules in its relation to the distribution of electrons and atomic nuclei in crystal lattices. These are: (1) The surfaces exposed tend to be electrically neutral; (2) weaker bonds tend to be broken rather than stronger; (3) if all bonds are equally strong, cleavage occurs between planes connected by the minimum number. Complete agreement is shown for the cases, diamond, zinc blende, wartzite, common salt, pyrites, calcite, aragonite, graphite, and antimony and bismuth metals. A. Wh.

1520. *Coordination Compounds and the Bohr Atom.* **N. V. Sidgwick.** (Chem. Soc., J. 123. pp. 725–730, April, 1923.)—Some ten years ago Werner succeeded in resolving certain of his coordinated compounds into their optically active components, and thereby definitely established the truth of his view of their sixfold structure. Since then structural chemistry has been in the unsatisfactory condition of having two incompatible theories, that of the inorganic chemist and that of Werner, each quite competent to explain the relations of its own group of substances, but neither capable of being extended with any success to cover the whole field. The object of this paper is to show that with the help of Bohr's recently published theory of atomic structure this can now be done. To explain the Werner sixfold structure Bohr's theory is considered in outline as to the relation of the groups in the periodic table. Bohr regards the electrons as rotating round the nucleus in orbits whose shapes are determined by the laws of ordinary dynamics, but subject to the quantum restriction, which makes a certain set of orbits alone possible, the arrangement of the orbits in an atom being arrived at by means of Bohr's correspondence principle resting on a mathematical analysis of possible orbits and largely supported by the evidence of the optical spectra. The arrangements in different atoms differ in stability, and chemical combination depends solely on the possibility of increasing this stability by a rearrangement of the orbits through the co-operation of two or more atoms. This stability cannot be increased in the inert gases, hence their inactivity. The development of the sizes of the successive groups of electrons is very fully discussed. In the well-established coordinated compounds it is shown that the octet theory does not apply, but that the octet is replaced by a group of 12 shared electrons, which is expressed by the Werner coordination number 6, and the stereochemical results show that these

six groups of atoms are arranged at the angular points of an octahedron. The second peculiarity of these compounds, *viz.* the apparent equivalence of univalent radicles and molecules of ammonia or water, as well as their behaviour on ionisation, can easily be accounted for on the ordinary principles of structural chemistry, and this is now correlated with the electronic theory, a number expressing the effective valency of the central atom being arrived at as follows, for every coordinated compound the ionisation of which is established: Every NH_3 or H_2O will contribute two electrons, one for the linkage, and one extra to make the nitrogen or oxygen quadri- or ter-valent. Each Cl or other univalent radicle will add one, for the linkage. Each (univalent) kation outside the bracket will also add one, whilst for every anion one must be subtracted; *e.g.* $[Co \,.\, NO_2(NH_3)_5]\, Cl_2 2 \times 5 + 1 - 2 = 9$. If this method is applied to all the coordinated compounds of ascertained structure, consistent values for each series are given, and to obtain from these the actual number of valency electrons, or electrons in the two highest quantum groups in the saturated atom, the number of electrons in the lower quantum groups (for the Fe series $2 + 8$, for the Pt series $2 + 8 + 18 + 32$, etc.) is subtracted from the atomic number and the valency number calculated from the compound added to the difference. A table of results is included. The complex cyanides show quite a different kind of regularity, the types $R_3 \times Cy_6$ and $R_4 - Cy_6$ prevailing, irrespective of the atomic number of $\times$; this makes it probable that in these cases the number 6 is due to some whole different cause, such as the formation of tricyanogen rings. The evidence adduced, however, is enough to show that the structure of those compounds for which Werner's doctrine of sixfold symmetry is most fully established can be explained, with the help of Bohr's theory, on the principles which have proved so successful in organic chemistry.

H. H. Ho.

1521. *Determination of the Dipole-Distance of the HCl Molecule by Electrostriction.* **O. E. Frivold** and **O. Hassel.** (Phys. Zeits. 24. pp. 82–86, Feb. 15, 1923.)—Debye's formula for the change of the dielectric constant with temperature contains a factor 1/3. From quantum considerations Pauli [Abstract 969 (1923)] replaced 1/3 by 1·54, so that $\mu_{kl} = 2{\cdot}15\mu_{qu.}$, where μ is the dipole moment and *kl* and *qu* stand for classical and quantum. Under certain conditions it should be possible to decide between the two formulæ. Falkenhagen and Weigt [Abstract 1343 (1922)] had meanwhile determined the dielectric constant of hydrochloric acid HCl, whilst Kratzer [Abstract 861 (1921)] had made measurements in the ultra-red; the dipole distance of the former was only about 1/3 of the core distance of the latter. The authors therefore determine the dipole distance of HCl by the method of electrostriction [Abstract 617 (1922)], modifying the illustrated apparatus for this purpose. The experiments proved very difficult because the insulation of the condenser failed suddenly in most cases, owing to the hygroscopic character of the HCl. The dipole-length deduced was smaller than that calculated from the dielectric constant and only 1/3 of the core distance; but the experiments do not admit of a discrimination between the two formulæ.

H. B.

1522. *An Investigation of the Structure of the Halogen Salts, based on their Compressibility.* **I. Woodward.** (Phil. Mag. 45. pp. 882–895,

May, 1923.)—The halogen salts crystallise in the cubic system, the atoms of the alkali metals and those of the halogens being arranged alternately at the corners of the cubes; the paper contains a calculation of the compressibility of certain cubic crystals of these salts based on Thomson's hypothesis [see Abstract 277 (1923)] that the octet of the halogen is completed by the single electron from the outermost shell of the alkali, and that these eight electrons lie at the corners of a cube, which, from considerations of symmetry, has its edges parallel to those of the cube of the crystal lattice. The salts examined were the chlorides, bromides, and iodides of sodium and potassium, and the chloride and bromide of silver. A calculation is also included of the specific inductive capacities of the chlorides of sodium and potassium. Throughout, satisfactory agreement is obtained between the calculated and observed values. Tables of data are included with illustrative graphs. H. H. Ho.

1523. *An Explanation of the Theory of the Rotation of the Atomic Nucleus.* **H. Henstock.** (Chem. News, 126. pp. 262–266, April 27; 321–325, May 25, and pp. 337–340, June 1, 1923.)—This is a continuation of a previous communication (Chem. News, 126. p. 129, 1923); the hypothesis brought forward is intended to explain the underlying cause of the theory of induced alternate polarity of atoms [Kermack and Robinson, Abstract 1794 (1922)]. The nucleus is assumed to have two positive poles at opposite ends of a diameter; and this nucleus axis may place itself in different positions with respect to the outer electron shell. This may produce induced polarity in the atom, or according to Lapworth, the atom has latent induced alternate polarity. This induced polarity, which is weaker than the permanent periodic polarity, explains the union of two atoms of the same element to form a molecule, or the union of carbon atoms to form a long chain in many organic compounds. Alternate atoms have opposite induced polarity, and the axes of the alternate nuclei point in different directions. It is the permanent periodic polarity depending on the outer electron shell which governs the formation of compounds like NaCl, where the Cl atom with seven electrons in its outer shell pulls away the solitary external electron of the Na atom, and the resulting ions Na^+ and Cl^- hold together by electrostatic attraction. In the author's first paper such a bond is called an electro valence bond. It is not quite clear whether this view is retained in the second paper. An edge of the octet cube of an atom, which has an electron at one end but none at the other, is capable of forming part of a single valence bond. If two vertical edges approach in such a way that the two electrons concerned are one at the top of its edge and the other at the bottom, and if the nuclei are oriented in the two atoms so that more lines of force pass out through one edge than through the other, the two edges will come together, and in the case of Cl, for example, two complete octets will be formed, united along one edge, the two electrons at the ends of this edge being shared between the octets. The formation of double and triple bonds is also considered and a number of rules are worked out which govern the action. Parts II and III apply the above principles to the cases of a number of compounds of the earlier elements in the periodic table. H. N. A.

1524. *Is there an Element of Zero Atomic Number?* **F. H. Loring.** (Chem. News, 126. pp. 307–308, May 18, and pp. 325–326, May 25,

1923.)—It is suggested that a single electron might be regarded as representing an atom with atomic number zero, since the atomic number represents the number of protons in the atom, and a single electron of course contains no protons. If the existence of an active element with atomic number zero is assumed, and if the number of active elements below each of the inert gases is subtracted from its atomic number, the series 0, 1, 2, 3, 4, 5 is obtained, but in the second part of the paper the author does not seem to attach great importance to these figures.

H. N. A.

1525. *Crystal Structure of Iron-Nickel Alloys.* **L. W. McKeehan.** (Phys. Rev. 21. pp. 402–407, April, 1923.)—The method used has been fully explained in connection with certain alloys of silver with gold and palladium. Fourteen alloys of different compositions were prepared from Armco iron and electrolytic nickel, and rolled into thin tapes; various heat treatments were applied, and X-ray diffraction patterns were obtained. With zero to 25 per cent. Ni the structure is chiefly body centred cubic, the parameter a increasing from $2{\cdot}872 \times 10^{-8}$ cm. for pure iron to about $2{\cdot}89 \times 10^{-8}$ cm. With zero to 70 per cent. Fe the structure is chiefly face centred cubic, the parameter a increasing from $3{\cdot}510 \times 10^{-8}$ for pure nickel to about $3{\cdot}60 \times 1^{-8}$. With about 30 per cent. Ni either structure is on the verge of instability, and the two may exist side by side. The atomic number of nickel is 28, and that of iron 26, so that there are two extra nucleus electrons in the former metal. It is suggested that in pure iron, with body centred cubic arrangement of molecules, each atom having eight equidistant neighbours, these neighbours are attracted by the eight faces of four elliptical electronic orbits; while in pure nickel there are six elliptical electronic orbits involved with twelve faces, which attract the twelve equidistant neighbouring molecules of the face centred lattice. The author considers that this assumption helps to explain the peculiar density relations between the different alloys; he suggests that the electrons responsible for the cohesion of metallic crystals are not the valence electrons, but those of a deeper layer. H. N. A.

1526. *Crystal Structure of Tin Tetra-Iodide.* **R. G. Dickinson.** (Am. Chem. Soc., J. 45. pp. 958–962, April, 1923.)

1527. *Quantum Theory of Polyatomic Molecules.* **M. Born** and **E. Hückel.** (Phys. Zeits. 24. pp. 1–12, Jan. 1, 1923.)—A. Kratzer's investigations into the band spectra of polyatomic molecules [Abstract 861 (1921)], more particularly of the diatomic molecules of the halogen hydrides, show that only by investigation of the interactions between the vibrational and rotational degrees of freedom can the finer structure be elucidated. His approximation method, however, is applicable only to heteropolar molecules. The present authors, by means of a method of quantising disturbed systems [see Abstracts 1955, 2114 (1922)], have obtained a very simple method, when applied to diatomic molecules, of expressing this interaction to any approximation desired, and on the assumption that the mutual potential energy of the two nuclei is a function only of the distance separating them. The only further assumption is that the electronic configuration remains unchanged, and this excludes electron "jumps" and therefore restricts the method to the

ultra-red portion of the spectrum. The case of diatomic molecules is first dealt with because the axis of rotation is then fixed in space, which greatly simplifies the procedure. Approximations for (1) small vibrations combined with rotations of arbitrary frequency; (2) small rotation frequencies. The general equations for polyatomic molecules are then developed, and these are extremely complex, but there are no mathematical difficulties to be overcome, only the trouble of laborious computation. The questions of numerical computation, with the exception of a comparatively simple case, are postponed for treatment in a paper to follow later. G. W. DE T.

1528. *Gravitational Field of a Particle on Einstein's Theory.* **J. T. Combridge.** (Phil. Mag. 45. pp. 726–732, April, 1923.)

1529. *Is Relativity Theory Based on Physical Foundations?* **N. v. Raschevsky.** (Zeits. f. Physik, 14. 2. pp. 107–149, 1923.)—*The Restricted Theory.*—The velocity of light in empty space is assumed to be a universal constant. What alone has been accurately measured is the time occupied by the forward and backward passage of a reflected ray over the measured distance separating the mirror from the source of light. It has been shown by de Sitter that if the backward and forward times are unequal, an irregularity in the apparent motion of the very distant spectroscopic double stars would be caused by the inequality, and might conceivably be observable. But in all other cases, *e.g.* of rays parallel and perpendicular to the direction of motion of the source, the constancy of the velocity appears to be not only unproved but unprovable. This and the other postulates of the theory are critically discussed and the conclusions drawn are to the effect that they are certainly not physical hypotheses, *i.e.* hypotheses which can be tested by observation, but purely mathematical conventions which appear at present as the most coherent and convenient for the representation of physical phenomena in general. They are, moreover, such that no research could possibly disprove them; but it may well happen, as our physical knowledge increases, that the whole scheme may become so complex that a simpler one may be sought and found.

Einstein's General Relativity Theory.—Here the fundamental assumptions are: The 4-space is not Euclidean, but has a curvature varying from point to point which is called into being and conditioned by the existence, distribution, and motion of the matter which it contains; the paths of material bodies are geodesics in this *world*. The light paths are geodesic null tracks. The first and fundamental assumption is what Poincaré has called an "indifferent" hypothesis, and the whole scheme can be rebuilt without it. For the representation of gravitational phenomena non-Euclidean geometry would appear to be the more suitable, but the conventional character of the geometry will persist. G. W. DE T.

1530. *Local Integration of Einstein's Equations.* **G. Darmois.** (Comptes Rendus, 176. pp. 646–648, March 5, and pp. 731–733, March 12, 1923.)—The author defines an exterior Einstein space as one in which the gravitation tensor vanishes and an interior space as one in which this is not the case. The exterior space is studied near a three-dimensional boundary. Make $g_{14} = g_{24} = g_{34} = 0$, $g_{44} = 1$, which is always possible, it being sufficient, given any three-dimensional surface

to take the geodesics normal thereto and to take x_4 as the geodesic distance of a point in the space from the surface. This being so, $ds_2 = dx_4^2 + \sum g_{\alpha\beta} dx_\alpha dx_\beta$. As there are only six unknown quantities, the whole space will be determined when $g_{\alpha\beta}$ and $\gamma_{\alpha\beta}$ are given, the former defining the fundamental form of the 3-space, and the $\gamma_{\alpha\beta}$ defining an invariant quadratic form, and the two forms may be regarded as determining an infinitely thin strip of 4-space to separate two parallel spaces.

In the second paper the start is made from interior to exterior, similar coordinates being used, and x_4 again representing the geodesic normal distance from a certain 3-space. It is then found that the pair of quadratic forms on either side of the boundary are prolongations one of the other, the values of the potentials and of their first derivatives all over one side of the boundary being equal to those on its other side. The interpretation of the boundary conditions is that the bounding surface $x_4 = 0$ must have as its generating lines the geodesics of the whole space, belonging to both exterior and interior space. For infinitesimal mass the classical definition of geodesics is obtained in exact form, not as hitherto approximately. The results can be extended to the case of the matter tensor appropriate to a perfect fluid, the method indicated being to assume the solution starting from the interior, and it is then easily verified; the interior ds^2 determines the external one, which is its prolongation. The author summarises the problem of n bodies thus: To each material mass is attached a quadratic form which is its interior ds^2. Each of these forms admits of but one prolongation into the external space, and they must be identical on opposite sides of the boundary provided the coordinate system be a unique one. The conditions determine, the author claims, as far as is possible the mutual dependence of the movements of the n bodies. But he admits that, even in the simple case of two bodies, the problem appears very difficult. G. W. DE T.

1531. *The Behaviour of the Measuring Rod in the General Theory of Relativity.* **W. Cauer.** (Phys. Zeits. 24. pp. 87–90, Feb. 15, 1923.)—The author here seeks to establish axiomatically the relationships which are generally valid between the ordinary and world geometrics, and to clear up the contradictory and incomplete statements which are to be found in the literature of the subject [see Abstract 455 (1917)]. Further it is shown that the velocity of light, when defined invariantly, never depends on the direction of the propagated light ray, and that the original physical significance of world metrics can be found, as in the special theory of relativity, from the characteristic behaviour of measuring rods and light signals. H. H. Ho.

1532. *Light Paths in Einstein's General Relativity Theory.* **W. van der Woude.** (K. Akad. Amsterdam, Proc. 25. 7 and 8. pp. 288–292, 1923. In English.)—In Einstein's theory the path of a light ray is found by expressing the condition that it is a geodesic null line in the space-time. If then the line element of the space-time be taken as $ds^2 = \sum_{ik} g_{ik} dx_i dx_k$, the light path satisfies equally the equations of the geodesic as those of the null line $ds = 0$. The author believes that the remarkable relation existing between these differential equations has

not hitherto been pointed out, and he here proves that it can be expressed as follows: *A geodesic having one point with the tangent at that point in common with a null line is itself a null line.* Let x_0 be the time coordinate. Then in 3-space at a point A an arbitrary direction is defined by giving definite ratios to $dx_l/dx_0 (l = 1, 2, 3)$. If, however, we assume these ratios to be given, we can give such values to dx_l/dx_0 that the condition $(ds/dx_0)^2 \equiv \sum_{\lambda\mu} g_{\lambda\mu} dx_\lambda dx_\mu / dx_0 dx_0 = 0 (\lambda, \mu = 0, 1, 2, 3)$ is satisfied. The theorem has, therefore, the physical meaning: *In 3-space a ray of light can pass at any moment through any point in any direction.*

G. W. DE T.

1533. *Tensor Equality and Relativity Dynamics.* **T. Y. Thomas.** (Phil. Mag. 45. pp. 177–181, Jan., 1923.)—Tensors and their components, which are themselves tensors, in Einstein's theory either represent physical quantities or are such that physical quantities are representable in terms of them. Hence the conditions of their equality are of fundamental importance. Two tensors of the same kind (contravariant, covariant, or mixed) and the same order are defined as equal if their corresponding components are equal in all coordinate systems, and from the laws of formation of tensors and components it follows that: If the corresponding components of two tensors of the same kind and order are equal in one coordinate system, then the tensors are equal; and as a corollary to this: If the components of a tensor vanish in one coordinate system, they vanish in every coordinate system. The components $A^{a_1 \cdots a_m} a_{m+1} \ldots a_n$ and $A^{b_1 \cdots b_m} b_{m+1} \ldots b_n$ of the tensor A are said to be of the same class if when $a_i = a_j$, $b_i = b_j$, and when $a_i \neq a_j$, $b_i \neq b_j$. The author here states and proves the following theorem suggested by a passage in Einstein's Princeton Lectures, which, with its two corollaries, provides a new set of conditions promising important applications: If one component α of a tensor A is equal to the corresponding component β of the tensor B, of the same kind and order as A, in all coordinate systems, then the corresponding components of the class of α and β are equal: Hence follow immediately corollary (1)—If one component of each class of a tensor A is equal to the corresponding component of a tensor B, of the same kind and order as A, in all coordinate systems, then A and B are equal. Corollary (2)—If one component of a vector (tensor of 1st order) is equal to the corresponding component of another vector of the same kind, in all coordinate systems, then the two vectors are equal (because the components of a vector are all of the same class).

Application to Special Relativity Mechanics.—Let M_0 be the stationary mass of a particle, x_1, x_2, x_3 the space coordinates, t the ordinary time, s the proper time, where $ds = dt\sqrt{1 - v^2}$, v being the velocity of the particle referred to light velocity as unity. Then the quantities $m_0 dx_\gamma/ds (\gamma = 1, 2, 3, 4)$ have a tensor character. Then it can be shown [Einstein's Princeton Lectures] that the quantities I_1, I_2, I_3, E, formed from the three (space) components of the momentum I and the energy E (time component), are also tensor-like. Assume, therefore, $E = m_0 dx_4/ds = m_0/\sqrt{1 - v^2}$. This is justified in that the expansion gives $E = m_0 + m_0 v^2/2 + 3m_0 v^4/4 + \ldots$, where m_0 equals the stationary energy E_0, while $m_0 v^2/2$ is the ordinary expression for the kinetic energy, and the remaining terms are negligible for ordinary

velocities. We have, then, two tensors of the first order with their fourth components equal in all coordinate systems, so that $I_\gamma = m_0 v_\gamma / \sqrt{1 - v^2} (\gamma = 1, 2, 3)$. And the force Q acting on the particle is given by $Q = \dot{I}$, or $Q_\gamma = dm_0 v_\gamma / \sqrt{1 - v^2} dt (\gamma = 1, 2, 3)$. Finally, if Q_4 be the work done on the particle in unit time, $Q_4 = dm_0 / \sqrt{1 - v^2} dt$, giving, with the preceding group of three equations, the four equations of motion of the mass point. To obtain the equations for a continuous distribution of matter, let P_1, P_2, P_3 be the force components on unit volume, and P_4 the work done on unit volume in unit time. It can then be shown [Weyl, Space-Time Matter, English Translation (1922), p. 166] that $P_\gamma (\gamma = 1, 2, 3, 4)$ has a tensor character. We have $P_\gamma dV = Q_\gamma$ and $dV = dV_0 \sqrt{1 - v^2}$, dV and dV_0 referring, respectively, to the moving and stationary volume element. From these and the mass-point motion equations, we find that $P_\nu = s_0 du_\nu / ds (\nu = 1, 2, 3, 4)$, where $u_\nu = dx_\nu / ds$, and s_0 is the stationary density of the matter. Since P_ν and $s_0 du_\nu / ds$ have tensor character these equations remain unchanged under all transformations by the original set of conditions previously referred to. G. W. DE T.

1534. *Causes of Earthquakes.* **R. D. Oldham.** (Nature, 111. pp. 432–434, March 31, 1923. Abstract of two lectures delivered at the Roy. Inst., 1923.)—The characters of earthquakes support the elastic rebound theory that earthquakes are due to the very slow growth of strain followed by a sudden release due to fracture. This theory could hold even in the case of sudden growth of strain, but the explanation fails to account for the complexity and intensity of some of the larger earthquakes. The Californian earthquake (1906) indicated a set of separate centres, widely distributed, independent as regards surface shocks, yet evidently connected with some common cause. Shallow earthquakes, which may be very destructive, do not give long distance records. Studies of such records indicate a depth of roughly 100 miles. These earthquakes are accompanied with surface fractures of shallow origin, but also by a bathyseism. As to the nature of the latter, it is suggested that it originates in a change in the bulk of subcrustal material such as may be produced by recrystallisation at some critical limit of temperature and pressure. Other causes, at present quite unknown, may conceivably operate. W. A. R.

1535. *The Galitzin Seismographs.* (Engineering, 115. pp. 474–477, April 13, 1923.)—Galitzin horizontal and vertical-component seismographs with recording apparatus, constructed by the Cambridge and Paul Instrument Co., are described and illustrated with photographs and drawings. The pendulum is suspended on the Zöllner method, and fitted with an electromagnetic damping device. This type of instrument was first designed and installed by Galitzin in the Pulkovo Observatory. W. A. R.

1536. *Tidal Stresses and Continental Displacements.* **H. H. Poole.** (Phil. Mag. 45 pp. 399–400, March, 1923.)—Taking Eddington's estimate of the earth's rotational retardation as measured by an increase in one century of the length of the day by 0·001 sec., the tangential stresses due to tidal action whether oceanic or crustal, even if considerable con-

centration of the tangential forces on particular areas should occur, would be quite incapable of causing appreciable relative movements involving distortion or fracture of the crust. So little is known of the subcrustal conditions, that it appears to be conceivable that the minute stresses due to tidal action might cause a slow rotational motion of the crust as a whole relative to the interior, as suggested by Eddington [Nature, p. 20, Jan. 6, 1923]. Otherwise it would seem that if tidal stresses have played a part in the history of continents it must have been in past epochs when, owing to crustal weakness or the closer proximity of the moon, they were far greater than now. G. W. DE T.

1537. *The Secular Acceleration of the Moon Determined from the "Almagest." A Correction.* **J. K. Fotheringham.** (Roy. Astron. Soc., M.N. 83. pp. 370–373, April, 1923.)—An error in an earlier paper is noted [Abstract 821 (1915)] and its results discussed. Finally the value for the siderial secular acceleration of the moon is corrected from $+ 10''\cdot 6$ per century to $+ 10''\cdot 3 \pm 0''\cdot 74$. A. Wh.

1538. *Greenwich Observations of the Moon.* **F. Dyson** and **A. C. D. Crommelin.** (Roy. Astron. Soc., M.N. 83. pp. 359–370, April, 1923.)—An analysis of the residuals between tabular and observed positions of the moon bringing up to date papers by Cowell [Abstract 30 (1906)] in which periodic terms were sought and the coefficients of known terms determined with greater accuracy. Cowell's analysis covered 133 periods of 400 lunar days. 19 extra periods have been embodied in the analysis and the results discussed. A. Wh.

1539. *Report of the Committee on Stellar Classification Adopted by the International Astronomical Union at the Meeting at Rome, May 10, 1922.* (Internat. Astron. Union, Trans. 1. 1922. Astrophys. J. 57. pp. 65–76, March, 1923.)

1540. *Constitution of Spiral Nebulæ.* **F. A. Lindemann.** (Roy. Astron. Soc., M.N. 83. pp. 354–359, April, 1923.)—The theory that spiral nebulæ are island universes does not explain many observed facts, such as the predominance of red radiation from their centres and their large recessive velocity. The theory is advanced that they are clouds of dust driven by radiation pressure into regions of low radiation density, where they form systems in equilibrium between gravitation and radiation. Their spiral motion may be due to tidal action. The nebulæ would move slowly about among the stars until ultimately they would be expelled from the galaxy by the radiation pressure. They would mostly escape in regions remote from the plane of the galaxy and would show huge recessive velocities, these appearing double the true ones, owing to their radiation being reflected and not intrinsic. The larger particles are in equilibrium closer together, and hence red scattering will predominate near the centre and blue round the outer layers. Apparent novæ are explained by collisions with clouds of meteors or dust. A. Wh.

1541. *Constitution of the Spiral Nebulæ.* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 83. pp. 382–385, May, 1923.)—Lindemann's suggestion

that the spiral nebulæ originated in dust clouds expelled from the galactic plane by radiation pressure is shown to be favoured by some considerations of the distribution and the radial velocities of these nebulæ. A diagram is given in illustration. His further suggestion that they shine by starlight reflected from the galaxy is not supported by their appearance, since the centres of uncondensed spirals are much the brightest part, and they are often surrounded by a ring of dark absorbing matter. Nor is it supported by their spectra, which sometimes show bright emission lines of hydrogen and nebulium. Polarisation gives no definite evidence of reflection, but further investigation should be made with longer exposures than have yet been tried. M. A. E.

1542. *Structure and Development of Stars.* **R. Emden.** (Phys. Zeits. 23. pp. 490–498; Disc., 498–499, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922.)—A description of the classification of stars into spectral types, with the general deductions from these of the absolute magnitudes, distance, volumes, and masses of stars, and their division into the two classes (as regards their masses) of giants and dwarfs. The latter part deals chiefly with the work of two men, that of Eddington on the radiation of a star, and of Megh Nad Saha on ionisation. A. S. D. M.

1543. *The Systematic Motions of Stars of Type A Deduced from their Radial Velocities.* **G. Shajn.** (Roy. Astron. Soc., M.N. 83. pp. 338–340, March, 1923.)

1544. *Constitution of the Four Outer Planets.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 83. pp. 350–354, April, 1923.)—The heat lost and gained by radiation for any planet can be calculated if the surface temperature be known. If the planet is fluid, heat is convected freely to the surface and cooling takes place rapidly, on solidification the process is much slower. Taking Jupiter's age as at least that of the earth (which is ascribed a lower limit by the radio-active equilibria in rocks), it is seen that the heat lost would have reduced it to a solid state on any possible assumption of initial temperature. A similar argument applies to the other three great planets. For Jupiter and Saturn, a limit to the depth of their atmosphere is set by considering the velocities of the monsoon and applying the theory of such winds in a homogeneous atmosphere. The velocities are determined by the difference in the rotation times of markings near the poles and the equator. The limiting depth of homogeneous atmosphere on Jupiter is 1/150 and on Saturn 1/20 of the planetary radius. The extremely low densities of these planets and their satellites suggests that they may be largely composed of ice or some similar material. The high albedo of Saturn's rings supports this view. **Erratum** (*ibid.* p. 480, June, 1923). A. Wh.

LIGHT.

1545. *Determination of Reflection Factors.* **W. F. Little.** (Am. Illum. Eng. Soc., Trans. 18. pp. 333–337; Disc., 357–365, April, 1923.)—The author defines "reflection factor" and explains the distinction between specular and diffused reflection. Methods of determining reflection factor, including the Nutting reflectometer and devices involving the use of the integrating sphere, are reviewed. A value between 0·98 and 0·99 is assigned to magnesium carbonate. The direct illumination from a source enclosed by a surface having a reflection factor r is increased in the proportion $1 + r/(1 - r)$. Hence in a sphere composed of magnesium carbonate ($r = 0{\cdot}98$) the illumination would be increased by 49 times the value existing in a sphere with a dead black interior. A curve relating reflection factor to increase in illumination is presented. J. S. D.

1546. *Refractive Indices of Solutions of Hydrochloric Acid, Acetic Acid, and Ethanol in Water at 25° and 30°.* **H. M. Elsey** and **G. L. Lynn.** (J. Phys. Chem. 27. pp. 342–345, April, 1923.)—The refractive indices at 25° and 30° are given for a number of solutions of hydrochloric acid, acetic acid, and ethanol in water. W. R. C.

1547. *Theory of Refraction by Black Screens.* **F. Kottler.** (Ann. d. Physik, 70. 6. pp. 405–456, March 20, 1923.)—The subject is treated in such a way as to show that the Kirchhoff theory gives valid results for refraction problems under all conditions. The paper is mainly mathematical and cannot be usefully abstracted. J. W. T. W.

1548. *Refractive Volume of very Dilute Solutions.* **C. Dieterici.** (Ann. d. Physik, 70. 7. pp. 558–560, April 5, 1923.)—From density data due to Kohlrausch and Hallwachs, and values of the respective refractive indices determined by Wagner for aqueous solutions of sodium chloride and sulphuric acid, the author shows that the respective values of the constant β in the Landolt relation $n - 1 = \alpha W + \beta S$, when $\alpha = (n_w - 1)v_w$ and $\beta = (n_s - 1)v_s$, the respective subscripts referring to the solvent and solute, are, for extremely dilute solutions of the order 0·001N, identical with the values, *viz.* 15·86 c.c. per mol. for sodium chloride and 23·00 for sulphuric acid, previously calculated for more concentrated solutions [see Abstract 651 (1923)]. The result is in agreement with the result obtained by Hallwachs, who failed to obtain optical evidence of an increased degree of dissociation accompanying increased dilution of a solution. J. S. G. T.

1549. *The Optical Cosine Law.* **T. Smith.** (Optical Soc., Trans. 24. pp. 31–39; Disc., 40, 1922–1923.)

1550. *A New Scouting Spectroscope for Prominences.* **O. J. Lee.** (Astrophys. J. 57. pp. 121–125, March, 1923.)

1551. *A Colour-Match Photometer.* **H. E. Ives.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 243–261, March, 1923.)—In the photometric comparison of sources which differ in colour use has been made of auxiliary standards which can be adjusted in order to give a colour-match with the illuminants studied. Instruments based on colour mixture have been devised, light from the red, green, and blue in the spectrum being combined. But such instruments have two drawbacks. If pure spectrum colours are used the blue element is relatively feeble. Also the comparison of a mixture of pure colours with the unsaturated hues of commercial illuminants leads to personal errors. The device now described utilises unsaturated yellow, green, and blue light, which suffices to enable the colours of all commercial illuminants to be matched. Light from a 400-w. lamp with filaments arranged in one plane passes through two plano-convex lenses, between which the coloured glasses are situated. The filament is focused on a ground-glass plate forming part of a small cubical box with whitened interior. The brightness of one side of this is compared with the brightness of a second white test surface, illuminated by the lamp studied. The two surfaces are brought into the photometer field by means of a special Lummer-Brodhun prism. The three coloured glasses are selected so as to be of equal transparency, and they are covered by a movable diaphragm such that the relative areas may be adjusted within wide limits, but the integral transmission of light remains constant. We have thus a source such that the colour of the light may be altered within wide limits while the candle-power remains constant, and this forms a convenient auxiliary standard in heterochromatic photometry. J. S. D.

1552. *The Regular Icosahedron as a Substitute for the Ulbricht Sphere.* **K. S. Weaver** and **B. E. Shackleford.** (Am. Illum. Eng. Soc., Trans. 18. pp. 290 300; Disc., 300–304, March, 1923.)—The determination of the efficiency of lighting units from polar curves of light distribution is tedious, and in some cases errors of 10–15 % arise. Hence the integrating sphere enabling a value for flux of light to be determined by a single reading is preferred. Attempts have been made to substitute cubical boxes, etc. The author recalls previous work, leading to the conclusion that the box photometer is useful for comparing sources of similar distribution but is not sufficiently accurate for those that differ widely in this respect. It was thought that the regular icosahedron would prove more accurate, and a 30-in. model was constructed, the twenty sides being cut out of heavy cardboard and bound together. A mathematical analysis of the action of this apparatus would be highly complex, and the authors confine themselves to experimental data. Thus the effect of position of the source and other variable factors is discussed and the efficiency of a lighting unit, determined respectively by this device and by using a 30-in. sphere, is compared. The values (47·7 % and 46·2 %) show fair agreement. In another case the efficiency was 75 % when determined by the icosahedron and 74 % when obtained from the distribution curve. It is found best to locate the observation window at an apex, as it then receives some light from all the faces. A high reflection-coefficient for the surfaces is of prime importance in view of the reliance

on multiple reflection to eliminate irregularities in distribution of light. There is little advantage in the icosahedron as compared with a 30-in. sphere, but for a larger apparatus simplicity of construction and greater interior roominess are distinctly helpful. It has therefore been decided to construct another model 10 feet high for more detailed experiments. J. S. D.

1553. *The Theory, Construction, and Use of the Photometric Integrating Sphere.* **E. B. Rosa** and **A. H. Taylor.** (Bureau of Standards, Sci. Paper No. 447. pp. 281–325, 1922.)—Part I deals with construction and use, Part II with theory. A brief survey of mirror integrators is first presented. Very accurate adjustment of mirrors is necessary, and such apparatus is unsuited for axially unsymmetrical sources. The sphere photometer has come into general use. Cubical boxes with whitened interiors have also been suggested. It is doubted if this apparatus is suitable where a higher accuracy than 2 to 4 % is needed, but it may be useful in certain cases, *e.g.* when the effect of some change in electrical conditions of a source in position is studied. The effect of approach to spherical form by blocking up the corners deserves study. The construction of the Bureau of Standards sphere, 88 in. diam., is next described in detail. Much attention has been given to the choice of paint for the interior, which should be (1) a perfect diffuser, (2) tenacious and somewhat elastic, (3) non-selective and permanently white, and (4) highly reflecting. On the whole a zinc oxide paint, though somewhat selective, was found the most suitable. The reflecting factor was found to be 91·9 %, and this was increased to 92·5 % by an extra coating. The effect of position of lamp, and absorption of light by the bulb, is discussed in detail. The greatest error is probably that due to placing lamps too near the sphere wall and making no correction for the light absorbed by them. In Part II such errors are more fully considered. The aim should be to make the screen as small as possible and the screened area a minimum. In the integration of a narrow cone of light it is shown that while the *absolute* error may attain 7·7 % the *comparative* error is within 1 %. The influence of a foreign body is lessened by making the sphere area large and for life-test measurements, where the absorption of light by a blackened bulb may be material, it may be advantageous to use a coating of somewhat lower reflecting power (*i.e.* about 80 %). A bibliography is included. J. S. D.

1554. *Theory of Flicker Photometry.* **C. E. Ferree** and **G. Rand.** (Am. Illum. Eng. Soc., Trans. 18. pp. 151–199; Disc., 200–207, Feb., 1923.)—The first part of the paper contains a review of previous work on flicker photometry, especially the comparison of results obtained by the flicker and "equality of brightness" methods. Factors which may affect results with flicker photometers include (1) colour of light, (2) intensity of light, (3) speed of flicker-disc, (4) relative lengths of exposure given to the lights compared, (5) size of field, and (6) state of adaptation of the eye. Observers in general agree in finding discordance between results obtained with flicker and equality of brightness photometers; some have found the Purkinje effect diminished by using flicker photometers, others have found it reversed. The variations in results of different observers appear to be due to the fact that time of exposure is an important element in flicker photometry. In the second part of

the paper the authors accordingly describe an apparatus enabling effect of length of exposure to be determined. Curves are presented showing that the period necessary for sensation to reach a maximum depends both on intensity and on colour. Curves tracing the rise in sensation stand in irregular relationship to one another and may intersect. This explains the discrepancies between results of different observers. For two given sources, at a certain intensity of illumination, flicker and equality of brightness photometers will give the same result. Above and below this intensity either underestimation or overestimation by the method of flicker, according to the colour compared with white light, is liable to occur. J. S. D.

1555. *A Distribution Photometer of New Design.* **C. C. Colby, Jr.,** and **C. M. Doolittle.** (Am. Illum. Eng. Soc., Trans. 18. pp. 273–284; Disc., 284–289, March, 1923.)—The author first reviews the usual types of mirror appliances to enable polar curves of light distribution to be determined, pointing out the merits and limitations of each form. The device adopted by the author comprises two mirrors: a large one receives light from the source and reflects it on to a second smaller mirror, whence it is directed on to a diffusing glass plate in proximity to the screen of a Lummer-Brodhun photometer. Photometric balance is effected by moving the comparison lamp, the Lummer-Brodhun photometer and the glass plate, serving as a secondary source, being stationary. The two mirrors are rigidly connected and rotate as one unit. Means are provided to enable the position of the source of light to be accurately adjusted. The methods of screening stray light and the various electrical accessories of the photometric bench are also described in detail. J. S. D.

1556. *Interference Phenomena in Lloyd's Mirror.* **J. B. Green.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 299–303, April, 1923.)—Discusses two phenomena which are observable in using Lloyd's mirror for producing interference fringes: (1) A gradual broadening of the fringes at the end of the interference pattern next the mirror, and (2) a periodic variation in the visibility of the interference fringes similar to a beat phenomenon. The author shows that (1) is due to diffraction by the edge of the mirror, and he shows mathematically that the fringes thus produced are of the same width as the interference fringes and in the same phase, so that the two systems match on to each other without a break. Under (2) it is shown that the variation in intensity of the fringes is due to the finite breadth of the slit, and that the distance between successive minima of the intensity is a function of the slit-width. The parts of the slit nearer the mirror give rise to a fringe system whose spacing is closer than that caused by the parts farther from the mirror, and the overlapping of the different systems causes the beat phenomenon observed. The author has tested his theory experimentally, with satisfactory results. J. W. T. W.

1557. *A Large Aperture Aplanatic Lens not Corrected for Colour.* **T. Smith.** (Optical Soc., Trans. 24. 1. pp. 22–29; Disc., 30, 1922–1923.)

1558. *Dioptrometer.* **H. F. Kurtz.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 103–125, Jan., 1923.)—The author describes in detail various forms of apparatus designed for measuring the powers

and other optical constants of spectacle lenses to the accuracy required for commercial purposes. The dioptrometer serves two important purposes: (1) The accurate laying out of all constants on a lens blank, preparatory to cutting it out for adjustment to the spectacle frame; (2) the checking of all the constants in the finished spectacle. The development of apparatus since the "Scharpf box" in 1877 is given, with discussions of the optical systems employed. In the most recent form light passes from a target through a standard lens on to the lens to be measured, which is held in a fixed position, thence to a telescope focused for infinity and possessing a fixation mark. The target is adjusted until it is in focus through the telescope, when the standard lens forms a virtual image of the target at a focus of the lens to be measured. The target carries an index to a scale which is divided to read in diopters. The standard lens is placed so that its outer principal focus coincides with the lens to be tested when the scale intervals are equal and the magnification of the target independent of the power of the lens tested. The target consists of two parts disposed along the optical axis, one for the measurement of spherical power, the other for the measurement of cylindrical power. Groups of vertical and horizontal lines are viewed for the spherical and cylindrical powers respectively, and when the image of the "sphere" target is found it may be kept intact while the "cylinder" target is adjusted. The construction and adjustment of the target is fully described. When the setting is finished the cylinder axis may be located within 0·5° for a ¼-diopter cylinder, while the focal power is found to within 0·03 diopter for low powers but somewhat less accurately for high powers. Decentration slides and scales are provided so that the prismatic power may be measured and the direction of decentration found. There is an inking device to mark the optical centre and cylindrical axis. Several other recent types of instrument are described with full illustrations. T. H.

1559. *Structural Colours in Feathers.* **C. W. Mason.** (J. Phys. Chem. 27. pp. 201–251, March, and pp. 401–447, May, 1923.)

1560. *Colour Measurement.* **L. Bloch.** (Zeits. techn. Physik, 4. 4. pp. 175–182, 1923.)—A colour measurer is described which depends on the measurement of reflected or transmitted light of the three colours, red, green, and blue. The illuminations of surfaces placed close together are compared, and for coloured bodies red, green, and blue glasses are used in the instrument. The apparatus can be used for opaque and transparent bodies and whether they are clear or dull. By its means the colour measurements described by Ostwald can be carried out, and examples are given of its practical use in various cases. J. J. S.

1561. *Some Curious Phenomena of Vision.* **F. W. Edridge-Green.** (Roy. Soc. Arts, J. 71. pp. 469–474; Disc., 474–478, May 25, 1923.)—The author explains various visual phenomena on the basis of the behaviour of the visual purple which is found in the rods and not in the cones. The function of the rods is to regulate the supply of visual purple. Decomposition of the photochemical film, sensitised by the visual purple, stimulates the end of the cones and sets up a visual impulse. Acuteness is greatest in the fovea where the cones mainly exist. The author contests the view that the Purkinje effect and other

familiar colour-phenomena are to be explained by assigning distinct visual perceptions to the rods and cones respectively, and quotes evidence to show that the impression that the eyes of some animals have only rods and no cones is ill founded. Curves relating (*a*) the amount of energy just sufficient to excite vision, (*b*) the bleaching effect of visual purple, and (*c*) the absorption of light by visual purple, with the wave-length follow very similar courses, thus supporting the belief that the basis of vision is a photochemical action. In the subsequent section of the paper various effects with after-images, notably their apparent motion in space, are shown to be in harmony with the theory which also explains the process of dark-adaptation. The Purkinje effect is not non-existent in the fovea, but in general is less marked than on the periphery. In the discussion the practical importance of these physiological effects in relation to glare of motor-headlights, etc., is pointed out. The author remarks that glare is mainly a matter of contrast, exemplified by the inconvenient effect of viewing pictures in the kinema theatre with dead black surroundings. J. S. D.

1562. *A Physical Study of Coma.* **L. C. Martin.** (Optical Soc., Trans. 24. 1. pp. 1–6; Disc., 7 9, 1922–1923.)—A specially designed microscope objective calculated to exhibit an appreciable amount of coma in the absence of spherical aberration and astigmatism is described in detail. By means of a special mounting the axis of the lens can be placed at any angle up to 10° with the axis of the microscope while the centre of its back aperture remains on the axis. Photographs of a "star" image taken when the amount of coma is equivalent to that for which the light distribution has been calculated by the author are found to verify numerical work carried out on a formula previously described [see Abstract 1553 (1922)]. The photometric examination of the photographic image is carried out by a special method. Two stars are found in which the intensity of the diffraction ring in one is equal to the intensity of the disc in the other. The ratio of ring to disc brightness is then approximately the same as the ratio of the areas of the two stars. J. W. T. W.

1563. *Laminar Diffraction and the Theory of Microscopic Vision.* **N. K. Sur.** (Indian Assoc. for Cultivation of Science, Proc. 7. 3 and 4. pp. 125–144, 1922.)—The mathematical theory as developed by Rayleigh, Lummer and Reiche, and Wolfke is applied in the present paper to determine the character of the images of different types of transparent structures under the miscroscope. The visibility of the structure depends upon the variations of phase of the light passing through it and not upon a variation of opacity. The image of a discontinuous laminar boundary is shown to be a place of minimum intensity bordered by fine equidistant fringes on either side. The position of the fringes is sensibly independent of path retardation on the two sides of the boundary. Next is considered the case of a transparent object with an echelon boundary of two steps. The images of the double boundaries are places of minimum intensity compared with the other fringes bordering them. For steps of a given width, the position of maxima and minima of illumination in the field is sensibly independent of the height of the steps. The nature of the microscopic image, however, depends on the separation of the steps, and the diminishing clearness of resolution with their closer approach

is illustrated by three graphs. In the case of a laminar transparent ridge, as the ridge becomes narrower, besides the diminution in the clearness of resolution of the two edges, the entire image tends to disappear, being replaced by uniform illumination. These results indicated by theory have been tested by observations under the microscope of various actual structures: (1) Striæ in mica, (2) air bubbles in a thin liquid film between two glass plates, (3) fine ridges of egg-albumen formed by drying up of a "mixed" plate, (4) fungus growths on glass, (5) botanical and petrographical slides of various kinds. While the results of theory are, broadly speaking, supported by observation, a certain asymmetry in the appearance of laminar boundaries is generally observed, which is unexplained by the theory. An explanation is suggested which, however, requires further investigation. The asymmetry becomes greatly magnified under oblique illumination. The close similarity between the theory of microscopic vision developed here and Rayleigh's theory of the phenomena observed in Foucault's test is pointed out. T. H.

1564. *A New Interference Phenomenon in Doubly Refracting Plates.* **C. Schaefer** and **K. Fricke.** (Zeits. f. Physik, 14. 3 and 4. pp. 253–284, 1923.)—Schaefer had observed two simultaneous sets of interference lines by reflection of the sodium D radiation from sheets of mica, the curvature of one set being greater than that of the other, so that the two sets intersected. When the plate is rotated about its normal through 90°, the curvature is reversed in direction, so that if the convex side of the curve is to the left originally it is on the right after the rotation; this change is repeated for further rotations of 90°. The theory of interference in *uniaxial* crystals is worked out in detail, and the forms of the interference curves for the ordinary and extraordinary rays are given for different directions of the axis with regard to the reflecting surface. For the experimental verification of the theory an Iceland spar crystal 4 mm. thick, cut parallel to the optical axis, was necessary; and this was obtained after some difficulty, as this section is very hard to cut. Two sets of photographs were taken, one with the telescope axis in the direction of the optical axis, with glancing angle of reflection (light was also obtained by transmission); a nicol enabled the two sets of curves to be photographed separately as well as together. The form of the curves agreed with the theory; and this was also the case when the telescope was perpendicular to the optical axis. H. N. A.

1565. *Dark Field Illumination with an Azimuthal Stop.* **A. Szegvári.** (Phys. Zeits. 24. pp. 91–95, Feb. 15, 1923.)—Side illumination in the dark field produces certain distortions; and various condensers have been designed to produce illumination from all sides, so as to avoid this. In certain circumstances, however, the azimuthal effect is advantageous; a minute rod or disc can be seen when it is at right angles to the direction of illumination; but not when it is end or edge on. A stop with a hole near its edge, placed below the condenser of the microscope, will cut off all light except that which strikes the slide at a certain azimuth, and can be rotated so as to obtain any azimuth desired. In practice two holes are used at opposite ends of a diameter of the stop. This gives two beams differing 180° in azimuth, but the effect is simply to give twice the illumination obtained with one hole, the azimuthal effect remaining the same. Such

a stop brings out points in the structure of sols which cannot be seen with the ordinary condenser. It is also useful in studying the " spark " effect, due to the Brownian rotation of rod- or disc-shaped particles, which flash into view when they turn into the proper position, and quickly disappear again as they rotate further. The stop can be used in the examination of microscopic and of ultramicroscopic particles. H. N. A.

1566. *Investigations on Radiometers.* I. *A Compensation Radiometer.* **W. Gerlach** and **H. Albach.** (Zeits. f. Physik, 14. 5. pp. 285–290, 1923.)—A complete theory of the normal radiometer has not yet been produced, while interest in the radiometer effect has again been revived by Ehrenhaft's " photophoresis," which depends on this effect on ultramicroscopic particles. Previous work is briefly mentioned, and is followed by a discussion of the principle of the compensation radiometer and its possible application for various measurements. Experimental details are then given of an instrument in which the radiometer vane is combined with an electrically heated bolometer in such a manner that the deflection produced by radiated heat is opposed by the corresponding effect under electrical control. The various difficulties experienced in the construction of such an instrument are briefly recorded. Finally its application is described for several particular cases. H. H. Ho.

1567. *Use of the Quantum Theory in Photochemical Sensitising.* **K. F. Bonhoeffer.** (Zeits. f. Physik, 13. 1 and 2. pp. 94–105, 1923.)—The validity of the Einstein equivalent laws have been proved already for a considerable number of photochemical reactions. One whole class of reactions still remain to be taken into consideration. They are those relating to sensitising. By this is meant the process by which the light absorbing molecule participates in the proper chemical reaction. Very little still is known of the nature of the energy transfer from the excited molecule to an inactive one. As the result of the present researches it is found that the sensitising of the decomposition $COBr_2 = CO + Br_2$ takes place through Br_2. In the sensitising of the decomposition of ozone by chlorine the Einstein equivalent law is fulfilled. The decomposition is two molecules per quantum. Possible explanations for this are discussed. It is confirmed that the decomposition velocity of the ozone, up to a very small concentration, is independent of the latter. From this independence is calculated the duration of activity of the excited condition with chlorine of at least 10^{-7} secs., if the diameter of the excited molecules is taken as equal to that calculated from the kinetic theory. With sensitising the decomposition of ozone through bromine vapour 31 molecules per absorbed quantum are decomposed. The reaction $CO + Cl_2 = COCl_2$ takes place several thousand times as quickly as the equivalent law demands. The combination of SO_2 and Cl_2 lies in about the right order of magnitude. A. E. G.

1568. *On the Theory of the Characteristic Curve of a Photographic Emulsion.* II. **F. C. Toy.** (Phil. Mag. 45. pp. 715–726, April, 1923. Comm. No. 27 from the British Phot. Research Assoc. Lab.)—For Part I see Abstract 494 (1923).

1569. *Fundamental Problems of the Photographic Plate.* **E. Mühlestein.** (Arch. des Sciences, 4. pp. 430–448, Nov.–Dec., 1922; 5. pp. 37–58,

Jan.–Feb., and pp. 110–128, March–April, 1923.)—These three papers are a review of the principal known facts relative to photographic plates and of the theories connected with them. The first paper deals with the different actions of light upon the photographic plate under the following heads: Properties and development of the latent image, properties and nature of the impression directly visible, the course of the reaction gelatino-bromide of silver + light, the action of light upon the gelatine. The second paper gives a résumé of the theories on the latent image dealing with it as follows: Grouping of the theories—the physical theories, the chemical theories, mixed theories, the defects of intensity, the defects of intermission. In the last paper the sensibility and structure of photographic plates is considered as follows: Definition and measure of the sensibility, factors which determine the sensibility, the rôle of the gelatine. It is stated that the following important problems still await solution: Lateral irradiation (propagation of the effects of light in the thick medium of the sensitive layer); the question whether there exists or not absolute distinctions between different luminous radiations, *i.e.* whether these radiations exercise specific actions upon the photographic plate; the actions of other forms of energy, of radiations of other nature, etc.; the effects of the superposition of the actions of different forms ot energy. The paper closes (pp. 120–128) with a detailed bibliography. A. E. G.

1570. *The Blackening of Photographic Plates by X-Rays and its Use as a Means of Measuring Intensity.* **A. Bouwers.** (Zeits. f. Physik, 14. 6. pp. 374–382, 1923.)—It is here shown that the blackening of a photographic plate by X-rays as a function of the time is given by the equation, $Z = C \log (t/\tau + 1)$ where C and t are constants. This formula is found by Busé to be applicable for ordinary light. For X-rays the exponent p in the formula of Schwarzschild $Z = f(It^p)$ with very close approximation = 1. The blackening law is also represented by $Z = C \log (It/a + 1)$. The constant C is not dependent on the wavelength, but increases asymptotically with the time of development. By means of photographic intensity measurements, the dependence of the intensity of the X-rays emitted by a tube on the current and tension is investigated [see also Abstract 136 (1922) for the work of Glocker and Traub dealing with the relationship between blackening and time of exposure and intensity]. A. E. G.

1571. *The Basis of the Einstein Equivalent Law and its Significance for Photochemical and Chemical Processes.* **F. Weigert.** (Zeits. f. Physik, 14. 6. pp. 383–409, 1923.)—Einstein's thermodynamic derivation for the photochemical equivalent law employs as basis an ideal perfectly reversible photochemical reaction. It leads to an expression for a stable photochemical equilibrium and also to the known equation, $\phi = N h\nu$, which affords the result that for the normal photochemical transformation N energy quanta must be absorbed, and moreover contains a relationship between the thermal effect of the entire reaction and the frequency ν. The physical impossibility for such a stable photochemical equilibrium is now referred to, and it is shown that the correct velocity of reaction established by Einstein for the photochemical part of the total reaction, $-dc/dt = Au_\nu c$, where A is a constant and u_ν is the radiation density for the frequency ν, only leads to a quantum expression when all the non-photochemical parts are excluded from the equations.

The equivalent law is valid, therefore, solely for the photochemical primary process in the form $q = N h\nu$, and signifies nothing for the total thermal effect ϕ of the reaction. Under the conditions found, purely chemical processes are likewise to be regarded as photochemical, and it holds quite generally that for every molar chemical or photochemical process N energy quanta must be absorbed. The resulting formula, $\mu_{\nu T} = ce^{-q/RT}/A = 8\pi h\nu^3 e^{-Nh\nu/RT}/c^3$, is identical with the van't Hoff-Arrhenius expression for the temperature dependence of a chemical reaction velocity, $k = Ce^{-q/RT}$, which forms the foundation of the radiation hypothesis of chemical processes. It is shown, however, that the assumption of Arrhenius which brings the activation energy q into relationship with definite thermochemical and optical properties of the chemical system considered is not in agreement with the completely unspecified nature of the expression $q = N h\nu$. The validity of this expression for all processes produced by radiation leads, in the best known special case of light-electrical effect, to the consequence that the physical significance of q is that N electrons are expelled from the element particles with initial energies independent of the nature of the electron yielding particles and given by the quantum condition $\frac{1}{2}mv^2 = h\nu$. Since every chemical process can be regarded as the consequence of an electronic displacement, the separation of an electron from a quantum orbit with the energy given by the above expression is in this case the primary process. All that follows afterwards, *e.g.* whether the electron returns to its mother particle or remains free, whether it produces mass displacement, etc., is without influence on the real primary process. All conclusions upon special mechanism can only be hypothetical under present experimental conditions, and the only method available appears to be one based on observations of light effects which depend specifically on the characteristic properties of the radiation excited, and up to the present these have only been made on the connection between colour and oscillation direction. The author's experiments, based on comprehensive qualitative data, led to exactly the same conclusions for the unspecific light-electrical nature of the photochemical primary processes as the theoretical considerations. These experiments gave the result, however, that the primary electronic expulsions afford only an actual radiation absorption when the electron does not return to its initial orbit but either springs, as in a Bohr atom, to a higher quantum orbit, or becomes free, or adheres to another electron-catching particle. The distance, vectorial orientation, etc., of the electronic emitter and receiver are proportional to the frequency and polarisation direction of the radiation which is actually absorbed. The initial energy of the expelled electron is related by the quantum condition with the frequency ν. The experiments advance therefore a step farther than the theoretical deductions, since they can give information as to why in different systems the same initial process leads with more or less probability to effective radiation transformations. In this direction quantitative experiments are now contemplated. H. H. Ho.

1572. *Modern Spectroscopic Apparatus.* **K. Försterling.** (Zeits. techn. Physik, 4. 4. pp. 182–188, 1923.)—Various formulæ are discussed which are applicable to the usual interference methods in spectroscopy, such as the diffraction grating, Michelson's échelon grating, and the parallel plates of Perot-Fabry and Lummer-Gehrcke. General relations

are obtained and from these laws specially applicable to separate apparatus are easily deduced. J. J. S.

1573. *Concave Grating and Interference Methods for Fine Structure.* **H. Nagaoka** and **T. Mishima.** (Astrophys. J. 57. pp. 92–97, March, 1923.)—The astigmatic property of the concave grating is used to cut out "fuzziness." Light is passed first through a Lummer-Gehrcke plate or an echelon grating, and then through the slit of the concave grating. Just as the transverse dust-lines are removed by a concave grating, so the fringes are drawn out and made more distinct. Photographs are given to illustrate. When using the Lummer-Gehrcke plate, the determination of the order of the fringes is much simplified by using two plates of different thicknesses. For absolute measurements it is admitted that the method of crossed spectra from two interferometers is preferable; but the present method will be of most use in connection with the Stark and Zeeman effect. A. C. M.

1574. *The Limitation of the Ultra-Violet Solar Spectrum.* **J. Duclaux** and **P. Jeantet.** (J. de Physique et le Radium, 4. pp. 115–120, March, 1923.)—The solar spectrum is limited on the side of the ultra-violet at the neighbourhood of the wave-length 2900 Å. The existence of ozone in the high atmosphere explains the extinction of the spectrum between the wave-lengths 2900 and 2100 Å., but does not explain why this spectrum does not reappear beyond for shorter wave-lengths. Experiments carried out by the authors show that the quantity of ammonia gas normally contained in the air is sufficient to explain the disappearance of the rays shorter than 2020 Å. about. On examining other causes of the enfeeblement of the spectrum on the side of the ultra-violet it is shown that if the solar spectrum is prolonged below 2900 Å. it is only in a narrow band near 2100 Å. This conclusion should be verified by experiments made as far as possible on a high mountain. While ozone only exists in the high regions of the atmosphere, ammonia is more abundant in the lower regions. J. J. S.

1575. *Zeeman Effect.* **E. Back.** (Ann. d. Physik, 70. 5. pp. 333–372, March 8, 1923.)—A determination of the Zeeman effect for beryllium, and for the diffuse series of BaCuTl. A special form of vacuum arc was employed, the pole-pieces of the electromagnet forming the "ends" of a horizontal cylinder. Photographs were made with the Tübingen grating instrument. The doublet and triplet separations of the spark and arc lines respectively of beryllium are considered (without magnetic field) in their relation to the values of the same quantities for the other alkaline earths. It is shown that the doublet separation for beryllium is too small, just as the doublet separation of lithium is too small compared with the other alkalies. New observations of fine structure for Tl were made, the different types of Zeeman resolution for the diffuse series were investigated and tabulated in the paper which are not suitable for abstraction. A. C. M.

1576. *Upper Harmonics in Infra-Red Absorption Spectra.* **C. Schaefer** and **M. Thomas.** (Zeits. f. Physik, 12. 6. pp. 330–341, 1923.)—Various observers, including the first of the above authors, have observed upper harmonics in the absorption spectra of different liquids and gases

[Abstract 1241 (1916)]; in the present investigation the twelfth of the CO band, the centre of which is at $4 \cdot 67\,\mu$, was found at $1 \cdot 573\,\mu$, the octave having been previously found by Burmeister at $2 \cdot 35\,\mu$. The intensity of the octave is given by Burmeister as about 1/14 of that of the fundamental, and that of the twelfth was about 1/14·3 of that of the octave; the double octave could not be found. The above wave-lengths do not correspond to frequencies having the exact ratio 1 : 2 : 3; and the strict theory does not require this, the correct relation being $\nu_0\,(1 - x) : 2\,\nu_0\,(1 - 2x) : 3\,\nu_0\,(1 - 3x)$. Calculating the wave-length of the twelfth from those of the fundamental and octave, by means of this relation, the value $1 \cdot 577\,\mu$ is obtained, which is very near the measured value. HCl gas has a pair of bands related to one another as fundamental and octave at $3 \cdot 46\,\mu$ and $1 \cdot 76\,\mu$, a weak absorption has now been found at $1 \cdot 190\,\mu$, the theoretical position for the twelfth being $1 \cdot 192\,\mu$. HF has a double band, with "centre of gravity" at $2 \cdot 52\,\mu$, which according to Imes is the fundamental; the octave of this has been observed at $1 \cdot 27\,\mu$, the twelfth, both here and in the case of HBr, lies in unfavourable regions for observation, and has not been found. HI decomposed during the observations, and gave no results. With solids cœlestin ($SrSO_4$) showed a fundamental at about $9\,\mu$ ($8 \cdot 35\,\mu$ and $9 \cdot 05\,\mu$) determined from the reflection curve; absorption measurements give the octave at about $4 \cdot 5\,\mu$, the twelfth with maximum absorption at $3 \cdot 02\,\mu$ and $3 \cdot 24\,\mu$, and the double octave forming a band between $2 \cdot 25\,\mu$ and $2 \cdot 35\,\mu$. Langbeinite shows the octave and twelfth and carborundum the octave; Iceland spar gives a complicated absorption spectrum, with numerous bands; reflection measurements show four fundamental wave-lengths; it was hoped that the absorption spectrum might be explained by means of the upper harmonics and combination vibrations of these; but this would lead to a still more complicated spectrum. It is hoped that higher resolution of the spectrum may lead to some definite result. H. N. A.

1577. *Explosion Spectra of the Alkaline Earths.* **R. A. Sawyer** and **A. L. Becker.** (Astrophys. J. 57. pp. 98–113, March, 1923.)—Anderson's method is used for obtaining spectra, but asbestos fibres soaked in a solution of the chloride of the metal are employed instead of wires [see Abstract 1063 (1921)]. The temperature of the explosion is estimated at about 15,000° C., and the pressure 10 to 20 atmospheres. The explosion spectra of Ba, Ca, Mg, and Sr were investigated with a six-foot grating. Lines due to impurities were very strong, showing how little material is required. The spectra are almost pure spark spectra, being chiefly diffuse and sharp doublets. Only the fundamental singlet 1S — 2P appears of the arc spectrum, and this has much less intensity relatively than in the vacuum arc. No lines of Cl, H, or O were detected. The results are discussed in connection with Saha's theory, and are shown to be in agreement with it. A. C. M.

1578. *Spark Spectra of Potassium.* **K. A. Nissen.** (Astrophys. J. 57. pp. 185–190, April, 1923.)—Series are calculated from the values found experimentally by McLennan [see Abstract 887 (1922)], Schillinger, and Nelthorpe. The wave-numbers were reduced to vacuum values. A system of five sharp series of the type $(2p_x) - (ms')$ has been traced ($m = 1 \cdot 5, 2 \cdot 5 \ldots$), and also a system of diffuse series; $(2p_v) - (md)$. The series consist of multiple lines, and the observed values agree with

the calculated values to one unit. The complexity of these spectra suggests the similar complexity of the argon spectra. A. C. M.

1579. *Fluorescence Spectrum of Benzene Vapour.* **W. H. McVicker** and **J. K. Marsh.** (Chem. Soc., J. 123. pp. 820–822, April, 1923.)—This refers to work undertaken in connection with the authors' investigations on the Tesla luminescence spectrum of benzene. No records of previous positive results exist, though the fluorescent spectrum in solution has been examined. Exposure of 100 minutes at a pressure of 3 cm. sufficed to show more than 30 bands on a photographic plate. The Tesla spectrum was recorded on the same plate. The structure of the two spectra were the same, but the intensities differed, the fluorescent spectrum being much weaker, although exposed for a longer time. A. C. M.

1580. *The Red Xenon Spectrum.* **L. A. Sommer.** (Zeits. f. Physik, 13. 1 and 2. pp. 85–93, 1923.)—This work was undertaken for the purpose of comparing the present spectrum with that of ionised cæsium. This comparison is to be reported upon shortly, the present being a preliminary communication. The measurements of Baly, Merrill, and Meggers are used in this first research. 148 lines are measured in the spectrum, 142 lines are arranged in pairs or groups. The tables given are divided into three sections, (1) A table of measurements, (2) Line pairs, (3) Line groups. The intensities are partly from the measurements of Baly, and partly from those of Merrill taken. A. E. G.

1581. *Critical Electron Energies in Helium and the Extreme Ultra-Violet Spectrum.* **A. C. Davies.** (Phil. Mag. 45. pp. 786–798, April, 1923.)—In a recent notice (see Nature, Aug. 26, 1922) Lyman reported the detection of several hitherto unobserved lines in the extreme ultra-violet spectrum of helium. Previous to this only one helium line had been detected in this region, and that by Fricke and Lyman [see Abstract 1436 (1921)]. In view of the fact that there is a difference (0·7 volt) between the value of the ionisation voltage for electrons in helium deduced from extreme ultra-violet spectroscopic observations by Lyman, and the value obtained experimentally by Horton and the author, and independently by Franck and Knipping, the possible sources of experimental error, or error of interpretation of results, in the case of the determination by Horton and Davies are discussed. It is shown that the discovery, made since the publication of the investigation in question, that there are two critical radiation voltages in the region of the first point of inelastic impact, separated by only 0·8 volt, introduces the possibility that an error of interpretation of the observed effects was made, resulting in values being attributed to all the critical voltages in helium which are too high by 0·8 volt + a small experimental error. Evidence is produced to show that the selection principle of Bohr, according to which only those transitions occur which involve a change of one unit in the azimuthal quantum number, cannot hold rigorously with regard to transitions to the normal state in helium. A possible explanation is given of the absence of certain lines, which are indicated by the current-voltage observations, from Lyman's photographic plates, and the question of the ability of the current-voltage method to reveal the existence of ultra-violet series lines is discussed. It is concluded that whereas the method may reasonably be expected to indicate the first lines of series involving

a return of the displaced electron to the normal orbit, it would probably not reveal the existence of the higher members of those series.
H. H. Ho.

1582. *Effect of Bromine Vapour on Nitrogen Bands.* **S. Datta.** (Astrophys. J. 57. pp. 114–120, March, 1923.)—A discharge tube containing bromine was connected to a side tube which could be immersed in freezing mixtures and so vary the pressure of the bromine vapour. The spectrum was found to give patches which were more or less blurred according to the pressure and which corresponded to the second positive bands of nitrogen. In later experiments the third positive bands were also obtained similarly blurred. In view of the low temperatures involved, it is considered unlikely that any compound of nitrogen and bromine is involved, but that the blurring is due to an effect of the strong electric field due to the electro-negative atoms of bromine. It is suggested that this Stark effect is responsible for the displacements found by other workers. A. C. M.

1583. *Hydrogen Spectra and Atomic Theory.* **E. Gehrcke.** (Zeits. techn. Physik, 4. 5. pp. 194–199, 1923.)—A review of past work on the spectra of hydrogen, together with a résumé of the quantum theory of the Balmer series. A. C. M.

1584. *A New X-Ray Spectrometer.* **W. E. Schall.** (Röntgen Soc., J. 19. pp. 50–52; Disc., 53–54, April, 1923.)—The author describes a portable form of X-ray spectrometer of Continental origin stated to combine the methods of Laue and the Braggs. A pencil of rays, *via* two lead slits, are incident upon a rotatable crystal, and the reflected rays are made visible by a fluoresent screen, the deviation being read on a scale in relation to the screen, and hence the wave-length is directly determined, or the instrument may be directly calibrated in wave-lengths. The author discusses the use of the instrument in medical work. In the *discussion*, various points were raised as to: The luminosity of the deviated rays on the fluorescent screen, the relation of voltage and wave-length at very high voltages (above 200,000), absorption of rays by the crystal, the protection of the observer, and the accuracy of the instrument, to which the author replied. B. J. L.

1585. *Vacuum Arc for the Range—Visible to Soft X-Rays.* **H. Nagaoka** and **Y. Sugiura.** (Astrophys. J. 57. pp. 86–91, March, 1923.)—This arc was evolved in order to provide a source of pure and intense lines, suitable for interferometer work. Kathode-ray bombardment produces suitable light, but is usually difficult to work with. In this arc the kathode is a carbon rod covered with a mixture of Ba and Sr oxides, and sheathed in a fused silica tube. The anode consists of the material to be investigated, also protected by a sheath of silica tubing. The kathode thus replaces the Wehnelt kathode previously used, described in Abstract 1565 (1921). The arc is started by connecting to the terminals of a small induction coil; when the kathode becomes faintly luminous the electrodes are rapidly switched on to the poles of a 500-volt d.c. generator. Using 80–150 volts, and $25\frac{1}{2}$ amps., very sharp lines are obtained, and the arc has great advantages as a standard source, since effects of pressure and electric field are obviated. But metals, especially

of low m.pt., tend to deposit on walls and windows; the oxide on the kathode needs renewing occasionally; the arc has a short life; running-water for cooling is advantageous, and continuous pumping out is required. With a potential difference of 1500 volts between the electrodes, photographic paper placed in the mouth of the flask was affected, showing the presence of X-rays. Calculated from the quantum relation, the wave-length should be of the order 10 Å.U. This is to be expected, since the apparatus does not differ essentially from a Coolidge tube. A. C. M.

1586. *X-Ray Investigations in Worked Metals.* **M. Polányi** and **K. Weissenberg.** (Zeits. techn. Physik, 4. 5. pp. 199–208, 1923.)—A popular account of previous work involving X-ray, crystallographic, and physical investigations. The idea underlying the work is that the anisotropic nature of fibrous structures is a statistical effect produced by the arrangement of the different crystals. A table is given of the different statistical possibilities arranged in classes of anistropy. A metal wire, stretched past the elastic limit, has been found to possess a fibrous structure, and the X-ray diagrams which would be produced by different classes are considered. These have been investigated experimentally for Cu, Pd, Al, Ag, Fe, Mo, W, Zn, in the form of wires; copper foil was also employed, and a general discussion of foil is included. [See Abstracts 702, 1182, and 2096 (1922).] A. C. M.

1587. *Some Points in the Physics of the X-Ray Tube.* **G. W. C. Kaye.** (Röntgen Soc., J. 19. pp. 84–87, April, 1923. Abstract of paper read before the Society of Radiographers.)—A general paper on various present-day X-ray problems, such as wave-lengths, high-voltage transformers, filters, protective material, X-ray tube efficiencies, etc. B. J. L.

1588. *Continuous X-Ray Spectrum.* **H. Kulenkampff.** (Ann. d. Physik, 69. 7 and 8. pp. 548 596, Jan. 4, 1923.)—An investigation is described of the intensity and spectral distribution of the continuous X-ray spectrum as the atomic number Z of the antikathode metal and the voltage V of the kathode rays are varied.

The X-ray bulb is provided with an aluminium window communicating with a Bragg spectrometer in which is mounted a calc-spar crystal.

The Z-relation was determined for 8 metals (Al, Fe, Co, Ni, Ag, Sn, Pt, Cu) for V = 10,470 volts; and the V-relation in the cases of Ag and Pt over a range of voltage 7000 to 12,000. A range of wave-lengths $\lambda = 1{\cdot}0$ to $\lambda = 2{\cdot}8$ Å.U. is covered in the measurements. The spectra obtained are affected by: (*a*) Change of angle which the observed X-ray beam makes with the surface of the antikathode and the absorption of the kathode rays in the metal of the antikathode; (*b*) absorption by the aluminium window and in the gas of the ionisation chamber; (*c*) reflection coefficient of the crystal and the length of the ionisation vessel. A linear relation was found to exist between ionisation I_γ and $\gamma_0 - \gamma$. The slope of this line is found to be proportional to Z; for different voltages (Z = const.) the spectra give parallel lines. In the neighbourhood of critical frequencies (outstanding spectral lines) "links" are observed on the ionisation curves —these are ignored in the above considerations. A. B. W.

1589. *X-Ray Spectroscopy of Organic Compounds.* **K. Becker** and **H. Rose.** (Zeits. f. Physik, 14. 6. pp. 369–373, 1923.)—The structure

analysis of a number of crystals of organic compounds has been previously undertaken by one of the present authors in conjunction with Jancke, and Bragg has also published [see Abstract 1781 (1921)] some results on the application of the ionisation spectrometer to the determination of the structure of minute crystals. A series of experiments on seven organic compounds is here recorded. The double molecule number of the unsaturated compounds as well as the difference of place and intensity of the interference maxima leads one to expect a moderately different lattice structure. The space lattice of the dibenzols do not originate from that of the stilbens by the addition of a second H-atom. Full details of the results obtained with each compound are given. A. E. G.

RADIO-ACTIVITY.

1590. *The Quantum Theory of Radio-Active Disintegration.* **S. Rosseland.** (Zeits. f. Physik, 14. 3 and 4. pp. 173–181, 1923.)—If an atom has a positive charge it is possible, with certain velocities of a colliding electron, for this to be bound by the atom in a stationary orbit, without the emission of radiation: it follows from consideration of the thermodynamical equilibrium of a mixture of atoms and electrons that the reverse process is possible, and that electrons may be emitted from an excited atom; thus an excited atom may be expected under certain conditions to emit wave radiation and under others corpuscular radiations. The author considers that the lines of groups 12 and 13 in Rutherford and Robinson's β-spectrum of RaB, and corresponding groups for RaC, as well as certain groups of photo electrons observed by de Broglie, are of this nature. He also concludes that it is possible that such β-rays may be produced in a system in which all the probabilities for wave radiation are zero. If a primary β-particle sent out by a radio-active process is due to absorption of a γ-radiation produced in the same nucleus, this must be much harder than any so far observed, the wave-length being of the order 10^{-11} cm. If this were true, some of this hard radiation would certainly pass outside the atom, in all substances which emit β-rays, and be capable of observation. The γ-rays which come from the nucleus of a disintegrating atom, and also the α-rays give a line spectrum, which fact speaks strongly for the theory that the nucleus is capable of existing in a series of stationary states, and emits monochromatic radiation (wave or corpuscular) in passing from one to another. For the β-rays the evidence is incomplete; Chadwick and Danysz both find that the β line spectrum is not important in comparison with the continuous background of the β-spectrum. Meitner, however, has obtained the line spectrum practically without any continuous spectrum, and ascribes the latter to instrumental imperfection. The author explains the theoretical possibility of the development of a continuous spectrum from β-particles leaving the nucleus with a single definite velocity. The circumstance that the velocity of radio-active disintegration is independent of the time can be looked on as a direct consequence of the quantum theory as applied to the nucleus. This follows from the results of a paper by Einstein on the relation between the quantum theory and Planck's law [see Abstract 654 (1917)].

H. N. A.

1591. *Methods of Demonstrating the Phenomena of Radio-Activity.* **P. Ludewig.** (Phys. Zeits. 24. pp. 138–141, March 15, 1923.)—Arrange-

ments are here described for demonstrating the fundamental methods of measurement employed in radio-activity. The principal points described are: The electrometer, experiments with α-rays from pitchblende and polonium; experiments with γ-rays; demonstration of secondary radiation; and experiments with α-rays from radium emanation. The experimental arrangements are illustrated by diagrams and examples of measurement results are given. A. E. G

1592. *Uranium V.* **A. Piccard** and **E. Stahel.** (Phys. Zeits. 24. pp. 80–81, Feb. 15, 1923.)—In a previous paper [see Abstract 579 (1922)] the authors have given their reasons for assuming the existence of a new radio-active element in the uranium series. O. Hahn considers the existence of this element, however, to be incompatible with his own observations. In the present paper the authors advance further reasons in favour of the existence of the new element, and reply to the objections raised by Hahn. A. B. W.

1593. *Anomaly on the Decay of RaEm in the Presence of its Active Deposit.* **F. Béhounek.** (J. de Physique et le Radium, 4. pp. 77–88, Feb., 1923.)—In her investigations on the radio-active constants of RaEm, Mme. Curie observed an anomaly in the decay of this emanation in the presence of the active deposit. The curve of "log ionisation" as a function of time, instead of being rigorously rectilinear after equilibrium had been reached, fell more and more rapidly (between 3 and 8 hours after removal of emanation), passed a point of inflexion and only then did the curve slope in accordance with theory. The object of the present investigation was to determine the exact position of this point of inflexion and to find the conditions which control it. It is found that the anomaly depends on the dimensions of the ionisation chamber (and condenser plates) and on the sense of the charge on the plates. The anomaly becomes less and less marked as the pressure in the ionisation chamber is reduced. A. B. W.

1594. *Utility of Normal Radium and Uranium Solutions for Emanation Measurements.* I. **P. Ludewig** and **E. Lorenser.** (Zeits. f. Physik, 13. 5. pp. 284–291, 1923.)—The paper commences with a description of the preparation of normal radium and uranium solutions, which is followed by an investigation of their utility and constancy, experimental details and tables of data being included. If the radium content of the uranium solutions be assumed to be proportional to the activity, then from the tables the normal solution corresponds to $3{\cdot}65 \times 10^{-9}$ gr. Ra. Experimental agreement between the standard solutions of the Physikalisch-Technischen Reichsanstalt and of the Freiberg Radium Institute is found to be within $0{\cdot}5\ \%$. Solution temperature is found to have no effect on the emanation measurement. During the course of a year the solutions do not appear to deteriorate. H. H. Ho.

1595. *Adsorption of Radium B and Radium C by Ferric Hydroxide.* **J. A. Cranston** and **R. Hutton.** (Chem. Soc., J. 121. pp. 2843–2849, Dec., 1922.)—This is a continuation of previous work [see Abstract 916 (1922)]. Radium B and radium C are adsorbed in proportions varying regularly with the acidity of the solution. At a given acidity the ratio

Th-B/Th-C adsorbed is greater than the ratio Ra-B/Ra-C adsorbed. This different behaviour is maintained when the adsorption is carried out in a mixed solution of the four radio-elements. These results are interpreted as evidence in favour of the colloidal theory put forward by the authors. On this theory a certain proportion of the B-members in 0·001 N-acid are pictured as existing in a state of colloidal aggregates of negative charge which with lapse of time, disintegrate partially into the C-members. These are held in the colloidal state and are adsorbed owing to the predominating influence of the remainder of the B-members. Hence the adsorption of the C-members is in greater proportion for the radium series owing to the period of radium B being less than that of thorium B. E. A. O.

1596. *A Preliminary Investigation of the Intensity Distribution in the β-Ray Spectra of Radium B and C.* **J. Chadwick** and **C. D. Ellis.** (Cambridge Phil. Soc., Proc. 21. pp. 274–280, Nov., 1922.)—Two theories have been advanced to explain the β-ray disintegration of radio-active bodies. Meitner [Abstract 1639 (1922)] put forward the view that the entire β-ray emission of a radio-active body consists of a series of homogeneous groups of electrons with definite and characteristic energies, whilst on Chadwick's theory [Abstract 2102 (1922)] the disintegration electrons form the continuous spectrum, the energy of emission of the electron from any assigned atom being variable within wide limits. The homogeneous groups are considered to be entirely secondary in origin and due to the conversion of γ-rays in the electronic structure of the radio-active atom, these γ-rays being emitted from the nucleus during disintegration. The experiments described in the paper were undertaken to endeavour to decide between the two theories. The results obtained support the view that the continuous spectrum has a real existence which is not dependent upon the experimental arrangement, and that any explanation of it as due to secondary causes is untenable ; also that its magnitude is roughly what would be expected if each disintegrating atom contributed one electron to the continuous spectrum. The experiments are being continued. E. A. O.

1597. *On the Gamma Radiations of the Radium and Thorium Series Studied by their Photoelectric Effect.* **M. de Broglie** and **J. Cabrera.** (Comptes Rendus, 176. pp. 295–296, Jan. 29, 1923.)—By irradiating different substances with γ-radiation from radium and mesothorium, and studying the β-radiation emitted with the apparatus described in a previous paper [Abstract 1624 (1922)], the authors have arrived at the wave-lengths of some of the lines in the γ-ray spectra of the radium and thorium series. The values of the wave-lengths of the five lines which were obtained with radium are 51·9, 42·6, 35·6, 30·2, and $20·6 \times 10^{-11}$ cm. Those of the five lines observed with mesothorium are 171·0, 59·7, 53·0, 37·0, and $29·7 \times 10^{-11}$ cm. The longest wave-length in the thorium series corresponds to an electron from the L ring. All the other lines both in the radium and the thorium series correspond to K electrons. The values of the wave-lengths in the radium series agree well with those previously published by Ellis [Abstract 1782 (1921)]. E. A. O.

1598. *Radio-Active Products in the Atmosphere and the Probability of a Solar Origin.* II. **H. Bongards.** (Phys. Zeits. 24. pp. 16–19, Jan. 1,

1923.)—In a previous paper [see Abstract 883 (1920)] the author has given the results of observations on the radio-active content of the earth's atmosphere. He now attempts to correlate these results with the occurrence of sun-spots. It is shown that the maximum emanation content of the atmosphere coincides with the sun-spot (Kalzium flochengruppe) maximum. A. B. W.

1599. *A New Method of Determining the Radium Content of Carnotite Ores and Other Products of Low Activity.* **V. F. Hess.** (Am. Electrochem. Soc., Trans. 41. pp. 287–301; Disc., 301–302, 1922.)—When carnotite or other materials are filled into the space between two concentric spheres, the gamma-ray effect in the centre of the inner sphere can be calculated. This formula was taken as a basis of a direct method of determining the radium content of these substances. The samples were filled in wooden containers which were closed hermetically. The gamma-ray electrometer was introduced into the centre. The observed ionisation, expressed in absolute units (E.S.U.) reduced to normal pressure and temperature, multiplied by certain constants, gives directly the radium content per gramme of material. The method is sensitive enough to give correct figures for material with 10^{-10} g. radium per gramme of material. It is very simple, and requires no chemical treatment of the samples before the measurements. The results on ore samples were compared with the results derived from the chemical analysis of the uranium content, and were found to be in good agreement. AUTHOR.

1600. *The Blackening Law for α- and β-Rays.* **W. Bothe.** (Zeits. f. Physik, 13. 1 and 2. pp. 106–112, 1923.)—This paper consists of remarks relative to a paper by H. Salbach [see Abstract 696 (1923)] bearing the same title. The present author has previously worked out [see Abstract 1629 (1922)] a photographic method of measurement for β-rays and has shown that for the action of β-rays from RaE on the photographic plate the Bunsen-Roscoe law is followed with very great accuracy. Salbach came to the conclusion that his results are not in accord with those of the author. It is claimed now that the researches of Salbach were undertaken with a preparation of small concentration and that as a result many disturbing influences were present. On the other hand, it is admitted that the author's claim that the law is valid, is based on results obtained with only one kind of plate and one method of developing, but he also claims that as no special kind of plate and completely normal development conditions were chosen, it can with some probability be accepted that the validity of the law is general. Further experiments are in progress to explain this want of harmony. A. E. G.

1601. *Theory of Back Diffusion of β-Rays.* **G. Wentzel.** (Ann. d. Physik, 70. 8. pp. 561–594, April 20, 1923.)—The back diffusion of β-rays is on the basis of known model representations (nucleus deflection in the Rutherford-Bohr atom) made to lead up to a theoretical treatment. The mathematical presentation is specially formulated for a research arrangement of H. W. Schmidt [Abstract 1831 (1907)]. The problem leads to an integro-differential equation which can be integrated by a strongly convergent series development. The intensities of back diffusion calculated in this way are in good agreement with Schmidt's measurements. In his arrangement an active layer of UrX was put on the surface of a

metal plate (Al, Zn, Sn, Pb) of variable thickness, and the intensities of radiation on both sides in connection with the thickness was measured. If the thickness was increased the intensity must decrease on one side in consequence of greater absorption, on the other side it must increase on account of more back diffusion. The true absorption coefficients entering into the formulæ for the back diffusion of the β-radiation (UrX) in Al, Zn, Sn, Pb were numerically determined with sufficient certainty with help of the similar formula (taking the back diffusing thickness as null) by adjustment with other measurements of Schmidt. They are only in rough approximation proportional to the masses. The apparent exponential decrease of intensity of a diffuse kathode-ray bundle is a scattering action. The intensity of the back diffusion is strongly dependent on the material and the thickness of the supporting plate; thus the "back diffusion constants" of Schmidt have not the signification of material constants of the back diffusing medium. These "back diffusion constants" in dependence on the back diffusing element may be represented by a strongly convergent exponential series of the form:

$$q = b_1\left(\frac{Z^2\rho}{\alpha A}\right) + b_2 \cdot \left(\frac{Z^2\rho}{\alpha A}\right)^2 + \ldots$$

where Z = nuclear charge number, ρ = density, A = atomic weight, α = true absorption capacity. The first coefficient of this series b_1 has, according to empirical determination for Schmidt's experimental arrangement, the value $0 \cdot 13$ gr.$^{-1}$ cm.^{2}. The independently calculated theoretical value is $0 \cdot 12$ gr.$^{-1}$ cm.^{2} J. J. S.

1602. *Theory of the Scattering of α- and β-Rays.* **J. H. Jeans.** (Roy. Soc., Proc. 102. pp. 437–453, Jan. 1, 1923.)—In this paper the author deals with the theory of the passage of a beam of electrified particles through matter. A detailed examination is made of a beam of particles subjected simultaneously to single scattering of the kind first considered by E. Rutherford and to multiple scattering of the type considered by J. J. Thomson. The paper is mathematical and does not admit of a short abstract. E. A. O.

1603. *The Scattering of β-Rays.* **W. Bothe.** (Zeits. f. Physik. 13. 6. pp. 368–377, 1923.)—It is usual to distinguish between single scattering and manifold scattering of α- and β-rays. The author has developed the theory of manifold scattering for the case where the number of separate deflections is so large that statistical methods can be applied [Abstract 433 (1922)]. These are intermediate cases where the number of deflections is not large enough for this, and which are not easily treated mathematically. The author proposes to speak of such cases as "mehrfachstreuung" (*multiple scattering* as opposed to the above "vielfachstreuung" or *manifold scattering*). Multiple scattering is not of great importance in the case of α-rays, since both single scattering and manifold scattering can be observed through large ranges; but for β-rays it is very difficult to get fairly pure, measurable, single scattering. Crowther's last measurements, and those of the author, deal with multiple scattering, though Crowther explains them as depending on single scattering. Let half the total intensity of the rays be scattered outside the angle ϕ for thickness t of scattering material; θ is the deflection of a

β-particle which passes through an atom at a distance ρ from the nucleus, Z is the atomic number, R the atomic radius, e the charge, m the mass, and v the velocity of the β-particle; then $\theta = aZ(1 - \rho^2/R^2)^{3/2}/\rho$; $a = 2e^2/mv^2$. From this ϕ is found to be equal to $aZ\sqrt{2\pi Nt}$, when the thickness is so small that single scattering takes place; N is the number of atoms per c.c. For manifold scattering $\phi = 2{\cdot}6\ aZ\sqrt{\pi Nt}$. In both cases when ϕ is plotted against t the result is a parabola; and when the experimental results are plotted it is found that, for small values of t, they lie along the first parabola; for large values of t along the second parabola; and for intermediate values of t between the two parabolas. In the first case there is single scattering, in the second manifold scattering, and in the third or intermediate case multiple scattering. Examining his own measurements, and those of Crowther, with different scattering materials, and for different velocities of the β-particles, the author finds fair general agreement with the theory; but certain irregularities appear; and it seems probable that the mutual action between the β-particles and the electrons of the K layer does not take place according to the classical theory; this will probably be the case when the energy of the β-particle is near to the removal or the resonance energy of the electron. The above views are supported by fresh experimental evidence, which appears to show a quantum absorption of certain β-particles by the K layer of gold. H. N. A.

HEAT.

1604. *A Recording and Integrating Gas Calorimeter.* **C. V. Boys.** (Engineering, 115. pp. 559–562, May 4, 1923. Engineer, 135. pp. 470–471, May 4, 1923. Paper read before the Royal Inst.)—A detailed description of the author's calorimeter.

1605. *Relations between Properties of Liquids.* **W. Herz.** (Zeits. Elektrochem. 29. pp. 110–111, March 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—From Trouton's rule, as revised by Nernst, and the Clausius-Clapeyron formula for the heat of evaporation at boiling-point, the author deduces a formula connecting the boiling-point of a liquid with its vapour pressure at any temperature. For non-associated liquids of medium boiling-point, the surface tension at its boiling-point may be calculated from the b.p., the density at the b.p. and the molecular weight; an approximate determination of the gas constant is also possible in these cases. The examples are mainly taken from organic compounds; in the case of carbon disulphide a strong discrepancy is found for unknown reasons. H. B.

1606. *On the Heat of Mixing of Normal and Associating Liquids.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 25. 7 and 8. pp. 309–318, 1923. In English.)—In the derivation of equations connected with mixtures of two liquids, various writers—including the author and van der Waals—made use of approximations some time ago which gave no account, even in approximation, of the heat effect. In some cases this neglected part may become of great importance, especially in the case of associated components. It involves the term $(p + a/v^2)\Delta v$, where Δv is the volume contraction. In "quasi-ideal" mixtures of two liquids (*i.e.* liquids the critical pressures of which are about equal) the effect is nearly always *negative*, that is, heat is liberated, and not *positive* as the earlier theoretical derivation indicated. The correct theory is now given for mixtures of normal components. The correct expression for w, the integral heat of mixing of n_1 gr. mol. of one component with n_2 gr. mol. of the other component is shown to contain a term $a\Delta v/vv_0$ which had previously been omitted. The value of Δv, the volume contraction, is seen to consist of two parts, the first being of the order δ^2 where the second is of the order δ. When the critical pressures differ little, δ is very small, and the second part (neglected previously) will certainly predominate. It is shown that some experiments by Katz on the volume contraction and heat of imbibition of amorphous and crystaline swelling substances are in accord with the conclusions arrived at in the paper. A further paper is promised, to deal with associated components, where the preponderating influence of Δv will be still more pronounced in consequence of the great variation of volume on dissociation of the double molecules. T. B.

1607. *On Heats of Mixing of Normal and Associating Liquids.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 25. 9 and 10. pp. 399–413, 1923. In English.)—This paper is entirely a mathematical treatment of the subject, and only certain features can be included in the abstract. The phenomenon of the maximum-density of water, for example, is shown

to find its explanation in the great value for the contraction in volume, so that below 4° C. the thermal expansion is even exceeded by the diminution of volume in consequence of the progressive dissociation of the double molecules. Above 4° C. the thermal expansion will predominate. The heats of mixing normal substances is shown to be = 0, or very slight (+ or −) when the critical pressures are about equal, and examples of this are given by mixtures of $C_6H_5Cl - C_6H_5Br$, $C_6H_5N(CH_3)_2 - C_6H_4(CH_3)_2$, $H . COOC_5H_{11} - CH_3 . COOC_3H_7$, and mixtures of the 3 xylenes 2 at a time. For the general relationship between volume change, critical pressure, and heat of mixing, data are given for toluene-benzene. Mixtures with CCl_4 as component all present deviations due to the association of CCl_4. Examples of recognised associated components are given, *viz.* $C_6H_6 - C_2H_5OH$, $C_2H_5OH - CH_3OH$, $C_2H_5OH - H_2O$. The paper concludes with some remarks on the values of a/v^2. [See preceding Abstract.] H. H. Ho.

1608. *Specific Heats of Polyatomic Gases at Low Temperatures.* **R. W. Millar.** (Am. Chem. Soc., J. 45. pp. 874 881, April, 1923.)—Assuming that the molecules have only translational energy, the specific heats of monatomic gases obey the equipartition law over a wide range of temperature. In the case of diatomic gases, however, this is not so. The experimental values decrease at first slowly, and then more rapidly, with decreasing temperature, and even at high temperatures do not attain the value predicted by the equipartition law. Eucken [see Abstract 517 (1912)] found that the heat capacity of hydrogen reached the value 3/2 R below 60° Å., and Scheele and Heuse found considerable decreases for N, O, CO, and CO_2. By a study of the specific heats of polyatomic gases it was hoped to determine whether or not the first increase in heat capacity above 3/2 R is due to rotational energy, as has usually been assumed, or to vibrational energy. The gas was passed through a calorimeter, or heat interchanger, temperatures being measured by thermo-junctions. The heat lost by the gas being equated to that gained by the calorimeter, the specific heat at constant pressure (C_p) could be determined. From this the values of C_v, and of C_{p_0} and C_{v_0}, the heat capacities at zero pressure, were obtained by the equations

$$C_p - C_v = -T(\partial p/\partial T)_v \left(\frac{\partial v}{\partial T}\right)_p \quad \text{and} \quad (\partial C_p/\partial p)_T = -T(\partial^2 v/\partial T^2)p,$$

combined with Berthelot's equation of state. In this way the specific heats of methane, methyl chloride, boron trifluoride, and hydrogen sulphide were determined from temperatures near their boiling-points to 5° C. It has been thus shown that the heat capacities of gases do not depend on the number of atoms in the molecule alone, but upon the masses of the atoms, the constraints, and the temperature. In the case of hydrogen sulphide the heat capacity increases with decreasing temperature, due to the heat of polymerisation and other causes. T. B.

1609. *Variation of the Specific Heat of Air with Temperature.* **J. R. Partington** and **W. G. Shilling.** (Faraday Soc., Trans. 18. pp. 386–390; Disc., 390 393, Feb., 1923.)—Very few experimental results of any value are available on the specific heat of gases at high temperatures. The method employed here is to measure the velocity of sound in air contained in a silica tube electrically heated, measurements being taken at intervals

of approximately 100° C. from room temperature up to 1000° C. A correction is applied for the diminution of velocity due to the tube [see Dixon, Campbell, and Parker, Abstract 605 (1922)]. From the velocity of sound in the gas, the ratio of its specific heats is calculated by means of the equation $C_p/C_v = V^2M[\phi]/RT$, where ϕ is the correction to the ideal gas state $= 1 - 9\pi\tau(1 - 6\tau^2)/64$, π being p/p_c, $\tau = T_c/T$, p_c and T_c being the critical values. C_p and C_v are then obtained separately from use of the equation $C_p - C_v = R[1 + 27\pi\tau^3/16]$.

The values of C_v (true) lie practically on the line given by $C_v = 4{\cdot}849 + 0{\cdot}000358$ T gm.-cals. Above this temperature the general indication of the results so far obtained is that C_v begins to increase more rapidly with temperature.

In the *discussion*, **A. W. Porter** said that the results were no doubt of much greater accuracy than any published hitherto. The errors in the calculated value of C_v would be, however, 6 or 7 times those made in measuring the wave-length. This would mean about 1 % error in C_v. Berthelot's equation, which was employed in the calculations, could not be trusted up to 1000° C. T. B.

1610. *Determination of the Vapour-Pressure of Metallic Arsenic.* **S. Horiba.** (K. Akad. Amsterdam, Proc. 25. 9 and 10. pp. 387–394, 1923. In English.)—The author has employed the method developed by Smits and Bokhorst to measure the vapour-pressures of both the solid and liquid phases of the grey modification of arsenic. Plotting $T \cdot \log p$ against 1 for the solid phase gives a good straight line between 550° C. and 700° C., showing agreement with the theoretical formula $T \log p = -\frac{Q}{4571} + CT$, in which Q is the heat of vaporisation. For the liquid phase this relation was shown to hold between 800° C. and 850° C. The melting-point obtained from the two vapour-pressure curves lies between 817° C. and 818° C., the corresponding pressure being 35·8 atm.; the same pressure was obtained by direct measurement at the triple point. The values obtained for the molecular heats of sublimation, vaporisation, and fusion were 33·6, 11·2, and 22·4 kg. cal. respectively. A. W. L.

1611. *Vapour-Pressure of Copper Oxide and of Copper.* **E. Mack, G. G. Osterhof,** and **H. M. Kraner.** (Am. Chem. Soc., J. 45. pp. 617–623, March, 1923.)—The results are given of the determination of the vapour-pressure of copper oxide by the dynamic method at various temperatures, a catalytic method being used for estimating copper in extremely small concentrations. The following values are given for the vapour-pressure: at 600°, 1×10^{-7} mm.; at 800°, 1×10^{-4} mm.; at 900°, 7×10^{-4} mm.; at 1000°, 1×10^{-4} mm.; at 1000°, however, the vapour represents a mixture of cupric and cuprous oxides. The heat of vaporisation for copper oxide over the range 600–800° is calculated to be 63,000 calories. The vapour-pressure of copper at 810°, which is almost 1200° lower than the temperature for any data previously recorded, is at least 5×10^{-7} mm. T. H. P.

1612. *Vapour-Pressures of Certain Hydrated Metal Sulphates.* **C. D. Carpenter** and **E. R. Jette.** (Am. Chem. Soc., J. 45. pp. 578–590, March, 1923.)—A very accurate thermostat is described and has been used in conjunction with a Bremer-Frowein tensimeter of special design

for measuring the vapour-pressures of hydrates. Certain new transition points have been located, that for $CoSO_4$, $7H_2O$ being at 45·1°, and that for $CdSO_4$, $\frac{8}{3}H_2O$ at 41·5°. The value for $MgSO_4$, $7H_2O$–$6H_2O$, previously found by van der Heide to lie between 48·0° and 48·5°, is 48·4°.

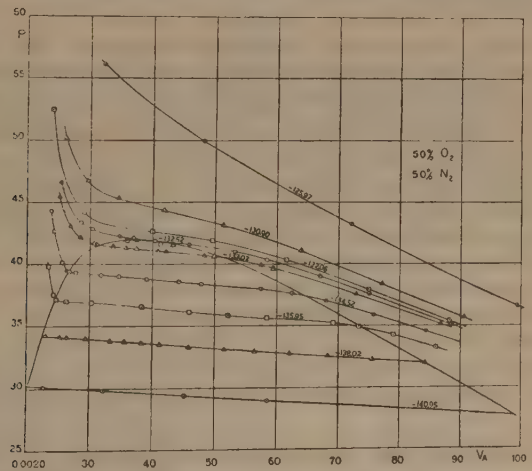
In the reaction $AB \cdot xH_2O + H_2O \rightleftarrows AB \cdot (1+x)H_2O + Qp$, Qp is given by the relation $Qp = RT^2 \frac{d \log p}{dT}$, and thus represents the heat of reaction per mol. of water at constant pressure, p being the pressure of water-vapour of the system at the absolute temperature T. The average values found for Q are: for $CuSO_4$, $3H_2O$, 13,256; for $CuSO_4$, $5H_2O$, 13,268; for $CdSO_4$, $\frac{8}{3}H_2O$, 11,170; for $MgSO_4$, $7H_2O$, 14,035; for $MgSO_2$, $6H_2O$, saturated solution, 9741; for $CoSO_4$, $7H_2O$, 12,795; and for $CoSO_4$, $6H_2O$, saturated solution, 9760. The value of Q usually changes most abruptly at the transition point, and is nearly constant so long as the same phases are present. On this account most transition points are readily located by the intersection of the lines drawn through the points determined by the log p and 1/T relationship. T. H. P.

1613. *Saturated Fluids near the Critical Point.* **G. Bruhat.** (J. de Physique et le Radium, 4. pp. 46-48, Jan., 1923.)—The author criticises an article by E. Ariès [Abstract 931 (1923)] on this subject, mainly in respect of errors of calculation, and refers to a previous article of his own [Abstract 1163 (1922)], the results of which show that Ariès' methods of approximation are non-reliable. An apology to Ariès is inserted by the editor that, by a material error, two paragraphs which he desired to withdraw had been published. G. W. DE T.

1614. *Analytical Treatment of the One-Dimensional Flow of Heat in a Homogeneous Plate.* **H. F. Zangger.** (Schweiz. Elektrot. Verein, Bull. 14. pp. 202-209, April, 1923.)—This paper forms an extension and corollary to that in Abstract 1421 (1923) above. The same method is used, and the case dealt with is that in which the heat source is not one of constant temperature, but of constant energy production; as, for example, a coil of wire heated electrically and placed between two flat plates. The temperature distribution is determined (1) during the warming of the plates; (2) during the cooling after the stationary state has been reached; (3) during the cooling from any given initial state. Graphical methods are used, and curves are given showing the distribution of temperature. T. B.

1615. *Isotherms of Diatomic Substances and their Binary Mixtures. XX. The Critical Curve of Oxygen-Nitrogen Mixtures, the Critical Phenomena and some Isotherms of Two Mixtures with 50 % and 75 % by Volume of Oxygen in the Neighbourhood of the Critical Point.* **J. P. Kuenen, T. Verschoyle,** and **A. T. van Urk.** (K. Akad. Amsterdam, Proc. 26. 1 and 2. pp. 49-64, 1923. Phys. Lab. Leiden, Comm. No. 161. In English.)—Before commencing the work at low temperatures, isotherms were experimentally determined for the two mixtures at 20° C. At the low temperatures isotherms were made over a range from about 5° above the critical point to 6° below that temperature for the 50 % mixture, and 2¼° below it for the 75 % mixture. The temperature intervals taken were, in the neighbourhood of the critical zone, $\frac{1}{20}$° C. or less. When two phases were present the pressure steps were only a few tenths of an atmosphere.

As soon as two phases were present, it was found that the equilibrium became extremely sensitive to the smallest change in pressure or temperature. In the critical zone an alteration of $\frac{1}{100}°$ in the temperature will cause the mercury in the stem of the piezometer to rise or fall by millimetres. The critical phenomena were well observed, both as regards the typical opalescence at or near the "plait-point," and the process of retrograde condensation. It was found possible to maintain the 50 % mixture under the plait-point conditions for over an hour, the blue opalescence being continually there, while an indefinite meniscus alternately appeared and disappeared in the middle of the bulb on stirring. The critical point of contact constants were found to be: (1) 50 % O_2 *mixture*, $p = 41{\cdot}90$, $v_A = 0{\cdot}00404$, $\theta = -132°{\cdot}53$; (2) 75 % O_2 *mixture*, $p = 45{\cdot}86$, $v_A = 0{\cdot}00375$, $\theta = -125°{\cdot}53$, where v_A is the critical volume, expressed in the normal volume. The "plait-point" constants were: (1) 50 % O_2 *mixture*, $p = 41{\cdot}90$, $v_A = 0{\cdot}00358$, $\theta = -132°{\cdot}66$; (2) 75 % O_2 *mixture*, $p = 45{\cdot}89$, $v_A = 0{\cdot}00336$, and $\theta = -125°{\cdot}60$.



For the critical point of contact temperature it was found that, at 0·01° above it no condensation was, of course, observed, and at 0·01° below there was a momentary, but very evident condensation. The P, V_A graph for the 50 % O_2 mixture is given in the diagram herewith.

T. B.

1616. *Simple Derivation of Planck's Radiation Law.* **J. Kunz.** (Phil. Mag. 45. pp. 300–303, Feb., 1923.)—By the Maxwell-Boltzmann law relating the average energy $\bar{U}$ of the molecules or oscillators in an enclosure of temperature T to the number dn, whose energy lies between U and $U + dU$, is modified by assuming dU replaced by a quantum of energy. The adiabatic hypothesis [see Abstract 403 (1917)] is then assumed, and shown to lead to Planck's quantum relation ($E = \gamma h$). Then $\bar{U} = h\nu/(e^{h\gamma/kt} - 1)$. But (Rayleigh and Jeans) the number of oscillations per unit volume in the frequency interval between γ and $\gamma + d\gamma$ is $do = 8\pi\gamma^2 d\gamma/c^3$, where $c = \lambda\gamma$, and dE in the same frequency interval $= do$, which gives Planck's law of radiation, $\partial E/\partial\lambda = 8\pi hc/\lambda^5(e^{hc/kT\lambda} - 1)$.

G. W. DE T.

1617. *Outline of a Theory for the Anisotropic Radiation Field. Part II.* **G. Jaffé.** (Ann. d. Physik, 70. 6. pp. 457–479, March 20, 1923.)—The present paper contains supplementary matter and generalisations of propositions in Part I [see Abstract 937 (1923)]. Section 5 deals with the integral equation for non-stationary processes. This is found to be a linear non-homogeneous equation of the second kind for the emission coefficients, and offers an immediate generalisation of the Hilbert equation for non-stationary events. Its solution may be developed in a series whose members can be found step by step by quadrature, and which quickly converge for the limiting case of weak absorption. Section 6 discusses non-homogeneous media; and shows that the methods developed in Part I for the homogeneous medium are applicable in the more general case. With strong absorption, differential equations are obtained which exhibit the closest relationship with those for the thermal conduction in non-homogeneous media, and the solution of the integral equation which is valid generally may be deduced as before by quadrature. The paper is entirely mathematical. H. H. Ho.

1618. *Thermodynamics and Statistical Mechanics.* **R. H. Fowler.** (Phil. Mag. 45. pp. 497–516, March, 1923.)—This is the fourth and concluding paper of this series [see Abstracts 65, 713, and 1484 (1923)]. The author shows that for dissociating assemblies in statistical equilibrium functions S and T may be defined, such that $dQ = TdS$, and having all the properties essential to entropy and absolute temperature in thermodynamics. Incidentally is established in the only completely logical way the relation between the empirical temperature θ and the absolute temperature T for such assemblies. Expressions are obtained for the entropy of the various groups of systems in the assembly which depend in a definite way on the number of systems in any group. It is shown, moreover, how the connection with thermodynamics can alternatively be made by means of Planck's characteristic function. Possible definitions of entropy for dissociating assemblies in connection with the increasing property are shortly examined; and this property is deduced for entropy, suitably defined, from the characteristics of statistical equilibrium. It is thus shown that there exists for the assemblies dealt with a function of their state, the entropy, possessing the requisite thermodynamic properties. Hence thermodynamic laws and their consequences are valid for such assemblies. It is shown, further, that Nernst's heat theorem must also be true for them. It is a direct consequence of the characteristics of statistical equilibrium, subject to the single condition that the weights of the lowest quantum states of the reacting systems are equal. There is every theoretical reason to suppose that this condition is fulfilled by all condensed systems, or at any rate by all crystals. This theorem and the resulting properties of the chemical constants are thus placed in their true perspective as theorems in statistical mechanics. It is not necessary to postulate the existence of entropy at any stage in the argument.

The general object of this concluding paper is to amplify the discussion of the second paper with the aid of the additional theoretical material now available. G. W. DE T.

SOUND.

1619. *Experiments with Telephone Receivers.* **W. Hahnemann** and **H. Hecht.** (Ann. d. Physik, 70. 4. pp. 283–290, Feb. 22, 1923.)—In previous articles [Abstracts 413 (1920), 208B (1921), 567B (1922)] some details have been given of the measurement of the mechanical-acoustical output and the efficiency of a telephone receiver. The present article is a continuation of the work, and specially deals with an improved method of finding the mechanical-acoustical efficiency, which, together with the electrical-mechanical efficiency, gives the overall efficiency of the receiver. The efficiencies are found from resonance curves obtained with constant power supplied to the receiver, and drawn with frequency as abscissæ and output derived from measurements of the electrical impedance as ordinates. The mechanical-electrical efficiency is obtained with the receiver held against the ear of the observer, together with measurements made with the diaphragm prevented from vibrating.

The determination of the acoustical-mechanical efficiency is dependent upon the determination of the damping and its analysis into two parts, useful and wasteful, the former due to useful work done in the inner ear, and the latter due to friction in the telephone diaphragm and in the the various air cavities. The useful damping is due to the yielding nature of the walls of the inner ear. Experimentally this may be made nil and the wasteful damping unaltered if the human ear is replaced by a dummy ear of similar volume and form as the natural ear, but constructed of hard unyielding material. This "hard ear" was made from a block of metal with a cylindrical channel 3 cm. long and 0·5 cm. diameter, terminating in a cone 0·5 cm. high and 2 cm. diameter. Resonance curves with the human and hard ears are drawn, and from the damping, δ_1 and δ_2, in the two cases the mechanical-acoustical efficiency is obtained, as $(\delta_1 - \delta_2)/\delta_1$.

Results are given of measurements on two special telephone receivers used in sound signalling. E. M.

1620. *New High-Frequency Light Relay for Photographic Records of Sounds on Speech Films.* **F. Aigner.** (Jahrb. d. drahtl. Tele. 21. pp. 101–120, Feb., 1923.)—A descriptive and mathematical paper devoid of diagrams, in which the author critically examines the requirements of the case and claims to have fulfilled them. E. H. B.

1621. *Method of Rendering Audible by Gramophone Graphical Records of Sound (Paka Method).* **G. Panconcelli-Calzia.** (Ann. d. Physik, 70. 3. pp. 250–254, Feb. 15, 1923.)—A brief mention of a method by which records of sound obtained in the ordinary or graphical method a surface can be changed to an outstanding or raised record, and so worked from for gramophonic reproduction as if engraved in the usual way. Fuller details are given in *Experimental Phonetics* (Sammlung Göschen, No. 844) and in the *Hamburg Experimental Phonetical Practical Work*, 1922 (Otto Meisner, Hamburg). E. H. B.

1622. *Whispering Galleries.* **C. V. Raman.** (Indian Assoc. for Cultivation of Science, Proc. 7. 3 and 4. pp. 159–172, 1922.)—The paper describes

the following five whispering galleries : (1) The Gol Gumbaz at Bijapur, (2) the upper gallery between the two domes of the Victoria Memorial at Calcutta, (3) the lower gallery under the inner dome of the Victoria Memorial, (4) the Granary at Bankipore, (5) the gallery at the Calcutta General Post Office. Of these (3) and (5) were discovered by the writer, and, in quality, (3) is not greatly inferior to the gallery at St. Paul's, London. The comparative study of (2), (3), and (5) leads to interesting results, notably the confirmation of Sabine's view of the importance of the inward slope of the wall of the gallery for giving the best effects and the concentration by a spherical dome of a maximum of sound at the opposite end of a diameter. Circumferential and radial nodal lines are observed in these galleries similar to those observed at St. Paul's. Further, the study of the propagation of impulsive sounds in these galleries shows that the multiple sounds are not echoes, but are due to the sound-waves travelling circumferentially round the gallery several times before they are sensibly extinguished. The sound is heard each time the waves pass the observer, and the smallness of the decrement in successive returns is a measure of the strength of the whispering gallery effect. The interval between successive returns is equal to the circumference of the gallery divided by the velocity of sound within an accuracy of 1 %. Waves travelling in opposite directions round the gallery can be differentiated by the ear. T. H.

1623. *Frequency of Circular Diaphragms.* **J. H. Powell** and **J. H. T. Roberts.** (Phys. Soc., Proc. 35. pp. 170 181 ; Disc., 182, April, 1923.) —The author describes determinations of the frequency natural to diaphragms of various sizes having a rigid rim and a central boss for attachment of a microphone or receiver. In air the frequency was found by means of a monochord, but under water the resonance-frequency was noted in the neighbourhood of a subaqueous transmitter of variable pitch. The results are in good agreement with the theoretical conclusions of H. Lamb [Abstract 285 (1921)]. In many cases partials were observed round about a fifth or an octave above the fundamental, but their occurrence was capricious and their pitch inconsistent with theory. The resonance peaks of the frequency curves are more or less of the same area, being high and narrow, or low and broad. The effect of increasing the pressure on one side of the diaphragm was studied, and the pressure-displacement curve was found linear up to the elastic limit, while the pressure-frequency curve is of the saturation type. A large diaphragm is less affected by pressure (and therefore by immersion in deep water) than a small one of the same natural frequency. The paper includes diagrams of the apparatus, tables, and graphs. *Discussion.*—**W. S. Tucker** elicited the fact that double resonance had been observed. **C. L. Fortescue** suggested that this might be due to the coupling of the two elastic systems, one of which is the structure supporting the diaphragm. **A. O. Rankine** questioned the propriety of calling the overtones " harmonics." E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1624. *The Electrodynamics of Ferromagnetic Bodies.* **E. Cohn.** (Zeits. f. Physik, 13. 1 and 2. pp. 48–58, 1923.)—An entirely mathematical paper developing (with certain restrictions) the equations for the electric and magnetic fields for the energy and the reciprocal relations. T. B.

1625. *Generalisation of Biot-Savart's Law.* **H. Poritsky.** (Phys. Rev. 21. pp. 360–364, March, 1923.)—Since electricity flows only in closed circuits, we may add to the field which Biot-Savart's law ascribes to an element of current an elementary field F, such that the effects of F, when summed for a closed circuit, will vanish. F may be termed a "null" field. Any generalisation of Biot-Savart's law differs from it by the addition of a null field. It is shown in two ways that all null fields are fields due to doublets coinciding with the elements of current, whose poles act with an arbitrary law of force. Since at each point the null field is perpendicular to the Biot-Savart field, the addition of a null field to the Biot-Savart law will only complicate it. This idea of null fields may be extended to closed surfaces and generalised to higher dimensions. No experiment could detect such null fields if they exist. A. W.

1626. *Apparent Dependence of the Electric Elementary Quantum, as determined by the "Schrot" Effect, upon the Frequency.* **W. Schottky.** (Phys. Zeits. 24. pp. 19–21, Jan. 1, 1923.)—R. Fuerth has attempted to explain the variations in the charge of the electron determined by the author, using the "sparrow hail" effect, on physiological grounds, by assuming that the observations were made very near the threshold of audibility [Abstract 541 (1923)]. The author shows that the sound observed by him had about 40,000 times the energy assumed by Fuerth; and was audible in an open room, when the telephone was at some distance from the ear. The physiological peculiarities of hearing investigated by Fuerth were observed in a closed cabin, the sound being so minute that it could only be observed by a rested ear. It is impossible that the variations observed in the author's experiments can have been caused by a physiological effect, which is only observed with sounds very near the threshold of audibility. H. N. A.

1627. *The Absolute Zero of Electric Potential.* **S. Bodforss.** (Zeits. Elektrochem. 29. pp. 121–123, March 1, 1923. Paper read before the Deut. Bunsen. Gesell., Leipzig, Sept., 1922.)—Christiansen observed in 1903 the movement of a drop of mercury on an electrolyte under the influence of a potential gradient. According to the concentration of the Hg ions the drop moves towards one of the poles; when the mercury is positively charged, it is negatively polarised in the direction of the anode, the surface tension increases, and the drop stretches out and wanders towards the kathode. When the ionic concentration is, by some addition, so diminished that the charge of the drop is reduced to zero, the movement ceases to proceed in the opposite direction of

further reduction of the $Hg^{\cdot\cdot}$ ions. This reversal was observed by Christiansen, but it did not represent the zero potential; for it depended also on the polarising current, since the mercury drop acts as intermediate conductor, in which mercury is dissolved at one end and deposited at the other. In place of the constant current of Christiansen, the author uses weak current pulses, interrupted by hand about every second, and watches the pulsations of the drop (there is no perceptible wandering with the short pulses) by means of a Zeiss stereoscopic microscope. The electrolyte is potassium-sodium nitrate, to which a little potassium cyanide is added to obtain a definite $Hg^{\cdot\cdot}$ concentration, although this addition of a complex salt is objectionable. The arrangement, with a calomel electrode in series was not very sensitive, and the reversion indistinct. Addition of hydrazine hydrate proved unsatisfactory. The reversion occurred at $-40 \pm 0{\cdot}02$ volt, *i.e.* when there is thermodynamically no charge on the drop, the potential of the normal calomel electrode should be $+ 0{\cdot}40$ volt. This value is lower than Palmaer's (1907), *viz.* $0{\cdot}57$, which was smaller than that of Ostwald and Paschen; but when the potassium cyanide solution is added, an absorption potential would be superposed, and the development of this potential would take time. H. B.

1628. *The Symbolic Methods of Heaviside.* **J. B. Pomey** and **J. R. Carson.** (Rev. Gén. d'Él. 13. pp. 813–820, May 19, and pp. 859–863, May 26, 1923.) I. *Preliminary Study by J. B. P.* II. *Complete Discussion by J. R. C.* III. *Notes by J. B. P. and J. R. C.*—Heaviside's symbolic method is little used in France, and M. Pomey's object is to call attention to it and to the recent work of Carson in investigating the rigorous mathematical foundation of Heaviside's methods which were largely inductive. It is shown that Heaviside's operational method is merely a symbolic or shorthand method of writing an integral equation. The paper is very mathematical and not suitable for abstracting. G. W. O. H.

1629. *Field of Electron on Einstein's Theory.* **S. J. Gunningham.** (Phil. Mag. 45. pp. 276–280, Feb., 1923.)—Hill and Jeffery have obtained a solution for the gravitational field of a mass-particle [Abstract 1000 (1921)]. Starting from the same expression for ds^2, and taking $\lambda = \mu$, the case for which they obtained an exact solution, the author obtains a solution for the field of an electron. G. W. DE T.

1630. *Quantum Theory and Electromagnetic Phenomena.* **W. Wilson.** (Roy. Soc., Proc. 102. pp. 478–483, Jan. 1, 1923.)—The author recalls the third postulate of the quantum theory which he proposed to add to Bohr's first and second postulates [see Abstracts 878 (1915) and 351 (1916)]. He mentions the fact that his postulate has been successfully applied in the investigation of the fine structure of the lines of Balmer's series and by Epstein in the investigation of the Stark effect. It can be applied without difficulty in cases where (as in the Stark effect) the atom can be treated as a conservative mechanical system of such a kind that the coordinates can be chosen in only one way, so that Hamilton's principal function S has the form $S = S_1 + S_2 + \ldots + S_f - Et$. When studying the motion of a charged particle in an electromagnetic field, from the point of view of Einstein's general relativity, we are naturally led to regard the quantum statements of this third postulate as special

cases of more general statements which the author here develops by aid of the tensor calculus, and applies to the Zeeman phenomenon in the case of a simple nuclear atom with a massive nucleus. G. W. DE T.

1631. *The Three Fundamental Constants of Electricity and Magnetism.* **Roy, Brylinski** and **Liénard.** (Rev. Gén. d'Él. 13. pp. 731–734, May 5, 1923.)—See Abstract 351 (1923).

1632. *The Behaviour of Slow Electrons in Inert Gases.* **F. Zwicky.** (Phys. Zeits. 24. pp. 171–183, April 15, 1923.)—The behaviour of slow electrons towards gas atoms has been studied experimentally by Townsend, Loeb, Mayer, Ramsauer, and Hertz. [See Abstract 1685 (1922).] The present paper gives a theoretical discussion of the above data restricted, however, to the inert gases, and without taking into account electronic affinity. In particular the experimental work of Ramsauer is followed, and the deviation experienced by a free electron is calculated when in the neighbourhood of a gas atom. Since actual atomic structures are unknown, several hypothetical types of atoms are considered, *viz.* rigid spheres, polarisable atoms, dipoles, quadrupoles. It is shown that in consequence of the phase relationships between the velocity of the electrons and the period of the oscillations in the field, decreases in the deviations occur with declining velocities, an effect which is general up to a certain limit. The paper is entirely mathematical, and deals with the subject under three sections, *viz.* polarisable molecules; the atom as an electrical system; the effect of the atomic field. H. H. Ho.

1633. *The Hypothesis of Sub-Electrons.* **L. Schiller.** (Zeits. f. Physik, 14. 1. pp. 6–13, 1923.)—The hypothesis of sub-electrons has been put forward by Ehrenhaft to account for the conclusion that the electrical charge on sub-microscopic particles of metals is, in some cases, calculated to be much below the accepted value of Millikan for an electron. The calculation is made from the Stokes-Cunningham equation: $eE = 4/3\ a^3\pi\sigma g = \frac{6\pi\mu a v}{1 + A l/a}$, where e is the charge on the smallest particle, E the arresting potential, a the radius of the particle, σ the density of the particle, μ the viscosity of the medium, l the mean free path, v the velocity of fall in a gravitational field, and A is Cunningham's factor. An alternative explanation by Bär [Abstract 2005 (1922)] regards the low value of e as being due to a deviation caused by the Brownian motion and by the assumption of a too great density of the particles which are considered to have a spongy structure.

In the present work it is concluded that the departures are due to the particles not being spherical, but of elliptical form, giving a relation in accordance with the equation: $eE = 4/3\ a_v^3\pi\sigma g = \frac{6\pi\mu a_h v}{1 + A l/a_g}$, where a_v is the radius of a sphere of the same weight as the particle, a_h the diameter of a sphere of the same hydrodynamic resistance, and a_g the diameter of a sphere of the same gas kinetic value. By means of data from different measurements, a discussion is given of the deductions that can be made of the axial relations of the particles. J. N. P.

1634. *Theory of the Action of the Earth's Potential Gradient in Measurements with the Ebert Ion-Counter.* **W. F. G. Swann.** (Phys. Rev. 21.

pp. 449–455, April, 1923.)—In a former paper [see Abstract 205 (1915)] the theory of the action of the negative charge induced on the ion-counter by the normal atmospheric potential gradient in causing error in the measurements of the negative ion-density was worked out for the case where the induced charge is insufficient to prevent the entry of ions at any point. The theory led to a linear relation between the reduction in measured negative ionic density and the potential gradient. The simple theory is now extended to take account of the action of the induced charge in not only changing the speed of the ions, but in reducing the area of the surface through which negative ions can enter the instrument. Assuming a simple ring distribution of the induced charge, an expression for the variation of percentage error or reduction in the measured negative ionic density with potential gradient is derived, and shows a non-linear law in general agreement with the observations of Mackell. In measurements of positive ion-density, the extended theory, like the simple one, indicates that no error is to be expected for a potential gradient of normal sign, a conclusion confirmed by recent results of Mackell and of Norinder. H. H. Ho.

1635. *A New Electrophorus.* **H. Wommelsdorf.** (Ann. d. Physik, 70. 2. pp. 135–138, Jan. 31, 1923.)—A double electrophorus of special design. P. E. S.

1636. *The Influence of the Earth's Potential Gradient upon Measurements of the Mean Ionic Density of the Atmosphere by the Ebert Ion-Counter.* **J. F. Mackell.** (Phys. Rev. 21. pp. 436–448, April, 1923.)—In this paper the effect of potential gradient upon measurements with an Ebert ion-counter for 35 to 115 volts/metre is determined. It was pointed out by Swann in 1914, that because of the negative charge induced at the upper end of the earthed outer shell by the atmospheric gradient, the density of negative ions as measured must be considerably less than the true value, while the density of positive ions is unaffected. Because of the wide use of the instrument for routine observations, it is important to settle the matter experimentally. Two identical ion-counters of the ordinary type were mounted 2 metres apart with axes normal to the outside wall of the laboratory and 1 metre from it. The true ion density N was determined by readings with the ion-counter shielded from the gradient by a large wire cage lowered over it; the differential effect of the gradient, ΔN, by readings made with shielded and unshielded counters connected to opposite quadrants of the electrometer; the potential gradient, by using a polonium plate connected to an electroscope. It was found that for the negative ions, the relative error $\Delta N/N$ increased linearly with the potential-gradient from 17 % for 35 volts/metre to 27 % for 115 volts/metre, whereas for the positive ions the average error was zero within the limits of accuracy of the experiment. These results are in agreement with the theory. H. H. Ho.

1637. *Supposed Relationship between Sunspot Frequency and the Potential Gradient of Atmospheric Electricity.* **C. Chree.** (Phys. Soc., Proc. 35. pp. 129–135; Disc., 136, April, 1923.)—From a study of observations at the Ebro Observatory, Tortosa, Spain, between 1910 and 1920, L. A. Bauer has concluded that the annual mean potential gradient of atmospheric electricity, and the diurnal inequality of the same element,

vary with the sunspot frequency. The present paper gives the results of a statistical investigation of the Ebro data, and also of the electrical and magnetic data for Kew for the two periods 1898–1909 and 1910–1921. For the magnetic data, in which case the relation with sunspot frequency is generally admitted, the mean correlation exceeds 0·92. The highest correlation obtained between potential gradient of atmospheric electricity and sunspot frequency is 0·72, which results from the Ebro observations. The results favour the existence of the relation stated by Bauer, but are insufficient to prove it. If this relationship exists, the influence of sunspots must be much less for atmospheric electricity than for terrestrial magnetism. A. W. L.

DISCHARGE AND OSCILLATIONS.

1638. *Induction Coil and Transformer Discharges with Coolidge and Gas Tubes.* **E. A. Owen** and **P. K. Bowes.** (Röntgen Soc., J. 19. pp. 78–83; Disc., 83, April, 1923.)—Reference is made to a previous paper [Abstract 135 (1922)] in which the authors found that with constant voltage the radiation intensity was not directly proportional to the mean current *via* the tube. This is contradictory to the results of other observers, and the present paper (in which both Coolidge and gas tubes, operated by an induction coil and by a transformer were used) endeavours to account for the discrepancies. The conditions of experiment are described and the results are discussed with reference to (*a*) relation between mean current and intensity, (*b*) quality of radiation emitted, (*c*) current and voltage wave forms, (*d*) relation between maximum and mean current.

The authors conclude: (1) The intensity of radiation emitted by an X-ray tube is not in all cases proportional to the mean current passing through the tube when the applied voltage is kept constant. (2) Considerations of voltage and current form, point to the conclusion that, for given voltage, and when maximum current is in phase with maximum voltage, the intensity of radiation of gas or hot kathode tube is roughly proportional to the maximum current *via* the tube, both for coil and transformer discharges. B. J. L.

1639. *A Study of the Luminous Discharge in Iodine. A Determination of the Ionisation Potential of Iodine.* **W. A. Noyes,** (Am. Chem. Soc., J. 45. pp. 337–342, Feb., 1923.)—In a previous article [see Abstract 123 (1922)], Gibson and Noyes studied the effect of certain gases and vapours on the emission spectra of metals. Measurements of the sparking potential were also made, and it was found that those gases which obliterated the spectra of metals also possessed high sparking potentials. The theory was advanced that heavy negative ions were formed due to the combination of the electronegative gases with electrons, and, that these ions could not be accelerated sufficiently with the potentials used to produce ionisation by collision. In another article [see Abstract 74 (1923)], the same authors presented a more quantitative study of the potential necessary to produce luminosity in a gas by measuring the glow potential at low pressures with a heated kathode. It was shown that this potential was a function of the ionisation potential of the gas, but both gases studied (hydrogen and mercury) had no appreciable effect on the spectra of metals. In the present paper results are presented

for the glow discharge in the typical electronegative gas, iodine, which show a marked obliterating effect on the spectra of metals. Part I contains a brief theoretical discussion based on the above theory. If the distance through which an electron will move before it attains ionising velocity is shorter in the case of iodine than for a gas such as hydrogen or mercury, then for the same length of tube a higher multiple of the ionisation potential would be expected, and the same theory applies in the region just after ionisation is produced since the electrons lose most of their energy on producing ionisation. This point was experimentally verified, *e.g.* in a tube 0·7 m. long, the glow potential for Hg was equal to the ionisation potential, while for iodine it was five times the value. Part II gives the experimental procedure, Part III the results obtained, and Part IV a brief discussion of the latter. The most probable value of the ionisation potential of iodine as determined in the experiments described is $10{\cdot}0 \pm 0{\cdot}2$ volts. This gives 8·4 volts as the ionisation potential of the atom, which would correspond to a wavelength of 1472 Å. It was found impossible to verify this from the spectroscopic data available. H. H. Ho.

1640. *Discharge in High Vacuum.* **R. Gans.** (Ann. d. Physik, 70. 8. pp. 625–628, April 20, 1923.)—It is pointed out that Epstein [Abstract 1088 (1919)] has previously treated the problem dealt with in Gans' earlier paper [Abstract 1200 (1923)], but that Gans has gone somewhat further by discussing the back e.m.f. and by simplifying the numerical calculations by means of the tables of functions given in his paper. Numerical examples are now given, which are compared with the experimental results obtained by Germershausen. A. W.

1641. *Centres of Luminescence and Variations of Gas Pressure in Spectrum Tubes at Electrical Discharges.* II. **L. Hamburger.** (K. Akad. Amsterdam, Proc. 25. 9 and 10. pp. 463 474, 1923. In English. Zeits. Elektrochem. 29. pp. 135–137, March 1, and pp. 142–144, April 1, 1923.)—Previous experiments made by the author [see Abstract 793 (1918)] showed that continuous-current discharge when passing through not too rarefied gases, gave rise to differences of pressure, the value of which, with sufficient current-density can amount to 30 % of the total pressure. In these investigations such variations of pressure were observed in numbers of gases of very different natures, as argon, neon, helium, nitrogen, hydrogen; it was found that the effects observed are very great in argon, hardly perceptible in hydrogen, and it was seen that the pressure effect must increase with the intensity of the current and with the root of the molecular weight. F. Skaupy has also found differences of pressure in continuous-current discharges in the case of noble gases. More recently (1922) A. Rüttenauer published an account of important experimental investigations in which the variations of pressure of noble gases were subjected to a closer examination, and the dependence of the effects found on different variables was given in an approximate "empirical" formula. The object of the present paper is firstly to show the author's priority with regard to the "positive" pressure effect, and then it is shown that A. Rüttenauer's experimental investigations quantitatively confirm the theoretical view and formulæ about the pressure effect previously found by the author. This confirms for an extensive region of validity that the pressure differences chiefly occur in consequence

of mass-transportation by the electric current. It is also found desirable to replace the empirical formula given by Rüttenauer for the pressure effect by two formulæ derivable from the theory, dependent on the ratio between the free path of the corpuscles and the (round) diameter of the tube, *viz.* $\Delta_p = f\frac{A\sqrt{Ml}}{D^3}\cdot\phi(g)$ resp. $\Delta_p = f\frac{A\sqrt{Ml}}{pD^4}\cdot\phi(g)$ in which $\phi(g)$ represents a function of the potential gradient, which can assume approximately the form bg in definite regions; in which b represents a constant the value of which is different for different gases. Δ_p represents the difference of pressure found, f a constant, A the current-density, g the gradient of tension, M the molecular weight, p the total gas pressure. It is shown that the opinion advanced by Skaupy that the pressure effect would be determined by the elastic electron impact, is untenable. The significance of the simultaneous parallelism of the quantitatively and objectively measured light and pressure effects with regard to the theory of the quanta is pointed out. It confirms that the atoms both emit and absorb energy in quanta. Attention is drawn to the desirability of extending the investigations, in particular also to argon. A. E. G.

1642. *A Glow Kathode Röntgen Tube for Work on Debye-Scherrer Data.* **F. Wever.** (Zeits. f. Physik, 14. 6. pp. 410–412, 1923.)—The Röntgen tube of Hadding [see Abstract 932 (1921)] serves admirably for experimental work on the Debye-Scherrer investigations, especially when combined with a rapid working pump and vacuum regulation by the current process. This may be a reason why the glow kathode tube has only received relatively little application in such work, and the present author now describes in detail with diagrams a simple metallic tube of this type which has been in use for the past two years. The tube is made of brass and is 50 mm. diam. and 300 mm. long, with a cooling jacket made of lead. The internal details are minutely described, and for these the original paper should be consulted. H. H. Ho.

1643. *Influences of Small Quantities of Water-Vapour on the Spark Potential in Nitrogen.* **H. Stücklen.** (Ann. d. Physik, 69. 7 and 8. pp. 625 627, Jan. 4, 1923).—The measurements obtained in a previous work [see Abstract 1813 (1921)] make it necessary to learn the influence of traces of water-vapour on the spark discharge in nitrogen. Moreover, such experiments have up to the present been performed in air and the phenomena depending upon ionisation by collision in a pure gas are often quite different from those which maintain in a mixture. The present experiments show that there is the same dependence of the spark potential upon the moisture in nitrogen as Meyer [see Abstract 1812 (1921)] found for air. Curves are given showing the relation (1) between potential in volts and time, (2) total pressure in mm. Hg and time, (3) potential in volts and pressure of water vapour in mm. Hg. A further curve shows that with sufficient drying, the discharge tension can take on a very high value. From a minimum of 308 volts it rises when the gas is sufficiently dry to the value 384 volts. A. E. G.

1644. *Observations on the Spark Potential.* **H. Stücklen.** (Ann. d. Physik, 69. 7 and 8. pp. 597–624, Jan. 4, 1923.)—In a brief introduction the findings of Townsend, E. Meyer, N. Campbell, and others are discussed. An especial form of apparatus is then described by which it is

possible to give a new surface by mechanical scraping to the plane parallel electrodes of a spark track in a vacuum. A series of protective measures is described for the purpose of avoiding the disturbance due to moisture alteration of the gas. The water layer which clings fast to the surface of the electrodes and is not loosened in vacuum exercises no influence on the spark potential. Renewing the surface appears to have no influence on the value of the discharge tension; it may be that such an influence does not exist or that the surface is very quickly covered again with a layer of gas or oxide. The experiments were carried out with brass, Cu, Al, and Ag in air and in nitrogen. Only in one case does a metal with a fresh surface show a different spark potential from that with the old. This happened with Zn in nitrogen. The influence of scraping then only occurs when done on the kathode surface, not on the anode. The spark delay which takes place if the electrodes have not been used for some hours disappears at once when a new surface is given to the electrodes. From this it is concluded that this form of delay depends on the surface properties of the electrodes in distinction with the usual spark delay which has its cause in the gas itself.

A. E. G.

1645. *Effect of Augmenting the Temperature upon Discontinuous Electric Discharge.* **G. Valle.** (N. Cimento, 25. pp. 87–114, Jan.–Feb., 1923.)—After a brief introduction the variations of the appearance of the discharge observed in a Plücker tube by means of a rotating mirror as the temperature is increased is described and schematically represented. Tables are also given showing details of the results obtained at different temperatures relative to the intensity of the current, potential differences in volts, and the nature of the discharge. Full details, with diagrams, are given of the experimental arrangements used. A. E. G.

1646. *Bräuer's Theory of the Function of the Kathode in Electric Arcs.* **A. Trowbridge** and **K. T. Compton.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 321–325, April, 1923.)—Experiments are described which verify Bräuer's measurements of the "post-arc" current obtained by suddenly short-circuiting an arc with a resistance of such value as to leave a small p.d., insufficient to ionise the gas, between the arc terminals, but which do not agree with his interpretation of them. A diagram is given showing the special arrangement of connections employed to give greater sensitivity to the galvanometer system when measuring the post-arc current. Readings are taken with two uncored carbon electrodes, and with the same electrodes used in conjunction with a massive copper block slipped over the anode at varying distances from the hot point, giving variations of cooling conditions. With increased rapidity of cooling, post-arc currents decrease more rapidly. Where a water-cooled copper anode is employed there is no trace of a post-arc current. It is argued that, contrary to Bräuer's conclusions, J. J. Thomson's theory that the principal part of the current in an electric arc is the thermionic current emitted from the hot kathode is supported. A. B. C. L.

1647. *Theory of the Electric Arc.* **K. T. Compton.** (Phys. Rev. 21. pp. 266–291, March, 1923.)—The chief data at our disposal are the kathode drop of potential, the anode drop, the electric intensity of the arc, the influence of the size and material of the electrodes, the nature

and pressure of the surrounding gas, the current, the spectrum and the intrinsic brightness of the arc, the mechanical reaction, and the back electromotive force at the electrodes. J. J. Thomson suggested that the current from the arc is chiefly of thermionic origin, consisting of the electronic emission from the kathode plus a relatively small current arising from ionisation of the gas by these electrons. Bräuer, after certain experiments and calculations, concluded (1) that thermionic emission accounts for only a few per cent. of the total arc current and the ionisation produced by thermoelectrons constitutes a negligible fraction of the current, and (2) that the electronic emission is due principally to the impact of positive ions against the kathode. Langmuir's values for the constants A and b in Richardson's equation $N = A\sqrt{T}\epsilon^{-b/T}$ for the thermionic current are by far the most reliable data available. In a gas in which electrons make inelastic impacts with molecules the limiting current-density i_i is expressed as follows:

$$i_i = 5{\cdot}45(10)^{-b}\sqrt{\frac{\lambda}{d}}\,\frac{V^{3/2}}{d^2} \text{ amps./cm.}^2$$

It is shown that Bräuer did not measure the thermionic emission, but only a fraction released as a result of the effect on the space charge of positive thermionic emission of the anode. The essential feature of an arc is an emission of electrons from the kathode which produce sufficient ionisation of the surrounding gas to give a positive space charge just outside the kathode. All other characteristics appear to be either consequences or prerequisites to this. If i is the current-density of electronic emission there must be a current-density of positive ions $j = i/242\sqrt{M}j$ to neutralise the space charge of the electrons, where M is the atomic weight of the ions. There must also be an additional positive current density J to give the excess positive space charge. It is found that $J = 1{\cdot}47(10)^{-7}\,\frac{V_c^{3/2}}{M^{1/2}\lambda^2}$ amps./cm.^{2} where V_c = kathode fall in volts, M = melecular weight of the positive ion, and λ = the electronic mean free path. By an application of this expression reasonable valves for J are obtained. The ratio of positive to negative currents is computed also from energy considerations at the kathode, the results being good evidence for the correctness of the theory. In the case of the carbon arc ionisation in the region between the electrodes must be sufficient to supply enough positive ions to neutralise the space charge due to electrons. Neither emission from the anode nor ionisation by collision will explain this ionisation, but it is primarily of thermal origin. Photoelectric ionisation occurs also to some extent. The author derives an equation for the current, and, if the temperature is 4000° K. or over and the ionising potential 8·6 volts or less the application of Nernst's heat theorem is sufficient to estimate the thermal ionisation. The anode fall is accounted for in a qualitative way. Probably also a second factor is a space charge very near its surface due to suppressed thermionic emission from it when it is hot. T. C. H.

1648. *The Anode of the Mercury-Arc Lamp.* **A. Günther-Schulze.** (Zeits. f. Physik, 13. 6. pp. 378–391, 1923. From the Reichsanstalt.)—Schenkel and Schottky have expressed doubts as to the values of the anode voltage drop obtained by means of probe electrodes; to test this

point the author employed a cylindrical anode of graphite, in the lower end of which a cylindrical hole was drilled; this was placed in a glass globe of 40-cm. diameter, and a probe electrode of tantalum wire was placed 1 mm. below its lower surface. The arc was practically confined to the inside of the hole. The temperature of the anode was measured by means of an optical pyrometer, at certain definite points, and from these measurements the total radiation from it was determined in watts. The current is theoretically almost wholly conveyed through the mercury-vapour by electrons; only about 1/400th part being due to the passage of positive ions from anode to kathode, so that the product of the anode drop and the current is nearly equal to the watts supplied to the anode, and the anode drop can be calculated; it amounted to 7·34 volts. Measurement with the probe electrode gave 7·36 volts, in satisfactory agreement with the result of the other method. The anode drop was shown to depend on the pressure of the Hg vapour; immediately after the arc was struck in a cold vessel it was 18 volts; but after heating, if the form of the anode was such as to conserve the excited Hg atoms, it dropped to a mean value of 4·8 volts; which was nearly constant from a vapour pressure of 0·22 mm. to 12·0 mm. The form of the anode had a strong influence on the anode drop; it was 10·4 volts in the mean with a polished iron sphere at low vapour pressure; and 8·9 volts, under the same conditions, when a hole was bored in the sphere in which the excited Hg atoms were preserved, and prevented from wandering away from the anode. Without the hole the current is not able to draw together at the lower end of the anode on account of the "stiffness" of the electrons. When a hole is bored the resonance radiation, produced by the current inside it, does not disappear by diffusion, as on the surface of the sphere; it is caught in the hole, and can only diminish by absorption at the walls; the excitation of the Hg atoms is therefore far greater inside the hole than outside, and the anode drop becomes considerably less. The effect of the material of the anode on the drop was investigated, and the results are given in a table. An uncertainty in their interpretation is pointed out. It was shown experimentally that, with constant vapour pressure, the anode drop is independent of the current and the anode temperature. The above experiments confirm the theory, which assumes that, in order to keep up the necessary slow flow of + Hg ions towards the kathode, Hg atoms have to be ionised at the anode. This can be done directly by electrons which have a velocity due to 10·4 volts. It can also be done step by step, if they have a velocity due to 4·68 volts, the impact of the first electron "exciting" the atom by driving one of its electrons into an exterior quantum orbit, whence further impacts may step by step remove it from the atom; radiation may also produce the same effect. H. N. A.

1649. *Explosive Potential in Gases at High Pressures and the Molecular Field.* **C. E. Guye** and **J. J. Weigle.** (Arch. des Sciences, 5. pp. 19–36, Jan.–Feb.; 85–96, March–April, and pp. 197–207, May–June, 1923.)—Mercier and Hammershaimb have previously shown that the law of Paschen $V = f(md)$ is verified experimentally at high pressures in nitrogen, when the discharge plays between two hemispherical electrodes of 15 mm. radius. Those authors attribute this result to the fact that the lateral diffusion, facilitated by the form of the electrodes, hinders the accumulation of ions in their neighbourhood, and so to modify the

electric field. On the other hand it has been found [see Abstract 987 (1922)] when using the same electrodes that in CO_2 this relationship does not hold good. $V = f(md)$ was found to be even less well satisfied than the ordinary formula $V = f(pd)$. It is now suggested that at high pressures in CO_2 there is formed a molecular field due to polarisation which helps to facilitate the passage of the discharge, and it is to study the influence of this field that the present experiments are carried out. In the first paper a full description with diagram of the apparatus employed is given, then an account of preliminary experiments. The results obtained with CO_2 are fully described, and it is concluded that notwithstanding the precautions taken the Paschen law is not completely verified. In the second paper experiments with nitrogen are described, the results obtained being in accord with those of Hammershaimb and Mercier. There is also a good deal of space allotted to theoretical considerations both in the second and third papers. In the third paper the general conclusions are given. The Paschen law is found to hold for nitrogen for pressures ranging from 1 to 50 atmos. An appendix gives a brief statement of the calculation of the electric moment of the CO_2 molecule, and there is a bibliography giving a list of the principal works which have recently appeared dealing with the electric moment of molecules and the molecular electrostatic field. A. E. G.

1650. *The Effect of Space Charge and Initial Velocities on the Potential Distribution and Thermionic Current between Parallel Plane Electrodes.* **I. Langmuir.** (Phys. Rev. 21. pp. 419–435, April, 1923.))—The paper deals with the case of parallel plane electrodes and first considers when the current is limited by space charge. The results obtained by Adams (unpublished), Epstein, Fry, and Laue are discussed and summarised, certain errors are pointed out, and the equations are put in a form adapted to easy numerical calculation. Assuming the normal components of the velocities of the emitted electrons have the Maxwell distribution, the integration of Poisson's equation between proper limits leads to a numerical relation between the new variables

$$\xi = 2(x - x_m)[2\pi^3 e^2 i^2 m/k^3 T^3]^{1/4} \quad \text{and} \quad \eta = e(V - V_m)/kT,$$

where x_m and V_m give the position and voltage of the plane of minimum potential, and k is the Boltzmann gas constant. Denoting values at the kathode by the subscript 1, and inserting values of constants: $n_1 = \log (i_0/i)$, where i_0 is the saturation current

$$V - V_1 = T(y - y_1)/11{,}600\,; \quad \xi - \xi_1 = 9{\cdot}18 \times 10^5 T^{-3/4} i^{1/2}(x - x_1).$$

These equations and the tables of $\xi(y)$ for various values of η enable, for a given kathode temperature T, the potential distribution for a given current i, or vice versa, to be computed. An approximate solution for the current is: $i = [(2^{1/2}/9\pi)(e/m)^{1/2}(V - V_m)^{3/2}/(x - x_m)^2](1 + 2{\cdot}66y^{-1/2})$, which reduces to the usual three-halves power law equation if we neglect V_m and x_m and the correction factor in y. Under Case II is considered the equilibrium condition with the anode at a great distance, and the current zero. If the only retarding field is that of the space charge, the density of charge is: $\rho = kT\rho_1/[(kT)^{1/2} + x(2\pi e\rho_1)^{1/2}]^2$ where $\rho_1 = i_0[2\pi m/kT]^{1/2}$. Except near the kathode this is approximately equal to $kT/2\pi ex^2$; hence ρ is proportional to the absolute temperature of the

kathode and inversely proportional to the square of the distance away. The potential gradient at the kathode is $X_1 = [8\pi\rho_1 kT/e]^{1/2}$. Equations are also given for Case III where an external retarding field X_∞ is applied. For concentric cylindrical electrodes the current is:

$$i = (8^{1/2}/9)(e/m)^{1/2}[V - V_m + \tfrac{1}{4}V_0\{\log (V/\lambda V_0)\}^2]^{3/2}/r$$

where V_0 is the initial energy of the electrons expressed in volts ($3kT/2e$), r is the radius of the anode, and λ is a constant between 1 and 2, not yet experimentally determined. The deviations from the three-halves power law are not more than one quarter as much as for parallel planes and amount to only about 3 % at 130 volts. H. H. Ho.

1651. *Influence of the Gas Content on the Thermic and Photoelectric Electron Emission of Platinum and Tantalum.* **R. Suhrmann.** (Zeits. f. Physik, 13. 1 and 2. pp. 17–34, 1923.)—The influence of absorbed gases on the thermic electron emission of metals has formed the object of many researches which have led to results of a very contradictory nature. In a brief introduction the work of Fredenhagen, Pring and Parker, Gehrts, H. A. Wilson, Richardson, Langmuir, Dushman, K. K. Smith, and others is referred to. In the present paper a full description of the experimental arrangements employed is given. A special method of degassing the metals is used, and it is found that the saturation current is very considerably lowered by the degassing. The constant A of the Richardson formula is now found to be for tantalum $7{\cdot}47 \times 10^{23}$ for less strong degassing and $2{\cdot}27 \times 10^{22}$ for stronger degassing, for platinum with less strong degassing it is $4{\cdot}76 \times 10^{27}$, for stronger degassing $7{\cdot}64 \times 10^{25}$. The constant b, and with it the work done, ϕ, remains constant for tantalum, and only alters very slightly in the case of platinum.

For tantalum, $b = 3{\cdot}64 \times 10^4$ $\phi = 3{\cdot}14$ volt.
For platinum, $b = 5{\cdot}791 \times 10^4$ $\phi = 4{\cdot}987$ volt for less strong degassing.
For platinum, $b = 5{\cdot}306 \times 10^4$ $\phi = 4{\cdot}569$ volt for stronger degassing.

The value $\phi = 4{\cdot}569$ volt is in good accord with that previously obtained by the author. A. E. G.

1652. *A Method for the Neutralisation of Electron Space Charge by Positive Ionisation at very Low Gas Pressures.* **K. H. Kingdon.** (Phys. Rev. 21. pp. 408 418, April, 1923.)—A very thin filament is passed axially through two holes in the closed ends of a cylindrical anode. Positive ions formed between the electrodes will seldom strike the thin wire, but missing it will, in general, describe orbits round it, until they lose their kinetic energy by collisions with gas molecules, and finally fall into the kathode wire. The effect should increase with the absolute temperature, and with the ratio of the cross section of the anode cylinder to that of the filament. The cylinder ends could be connected to the anode, or to the kathode in the apparatus used, the effect looked for being observed in the former case, but not in the latter. In favourable cases the current was five or ten times as great as that limited by the space charge. The effect is much greater with Hg than with He, which agrees with theory. Experiments made with the oscillograph to study the way in which the current grew to its full value, when switched on, confirmed the author's theory. H. N. A.

1653. *Photoelectric Sensitiveness of Palladium-Silver Alloys Charged with Hydrogen.* **F. Krüger** and **A. Ehmer.** (Zeits. f. Physik, 14. 1. pp. 1–5, 1923.)—Further evidence is derived to support the view that the photoelectric sensitiveness of metals is determined by the presence of occluded hydrogen. It has been shown by Sieverts that the greatest absorption for hydrogen is possessed by palladium-silver alloys, the maximum absorption being obtained with an alloy of 40 % silver. Measurements are made in the present work of the ionisation obtained on exposing alloys of Pd-Ag in varying proportions to the light from a mercury-vapour lamp. The alloys are made up as thin discs 8 mm. square varying in composition in steps of 10 %, and mounted around the periphery of a rotating system so that the individual discs can be exposed to the beam of light which is admitted through a quartz window and is concentrated on to the disc by means of a quartz lens. The enclosure containing the discs is heated by a surrounding wire coil through which a current is passed and a temperature of 160°–180° C. maintained. The rotating discs are connected to one pair of quadrants of a Dolezalek electrometer, while an adjacent metal cylinder through which the beam of light passes is earthed. The apparatus is filled with purified hydrogen and saturation of the alloy attained before each measurement. With the different alloys a close parallelism is found between the photoelectric effect as measured by the electrometer displacement and the solubility of the hydrogen, the maximum effect being given by alloys containing 40 % silver. [See Abstracts 717 (1914), 1687 (1922).] J. N. P.

1654. *Effect of Current on the Photoelectric Sensitivity of Metals.* **A. G. Shenstone.** (Phil. Mag. 45. pp. 918–926, May, 1923.)—Experiments have shown that the photoelectric sensitivity not only of bismuth but also of a number of other metals is temporarily increased by the passage of a current. The author after describing the apparatus used, goes into the question of the effect of temperature, and to ascertain in the case of a bismuth plate what was taking place, a constantan-copper thermojunction was soldered to the back of the plate, the flattened leads being led out through the de Khotinsky cement in the ground glass seal. It was found that the temperature rise corresponding to a rise of photoelectric current of 16 % was less than 5° C. and corresponding to 30 % was only 24° C., so that is very improbable that the changes of photoelectric current can be ascribed to changes due to temperature. A series of experiments is described and the not unnatural conclusion is drawn that the condition produced in a metal surface by an electric current is permanent until a considerable rise in temperature takes place. Observations on bismuth warmed without the use of current and on copper cooled while current is passing give strong evidence that the effect is not produced by the heating due to the current. The author concludes that the changes of photoelectric sensitivity observed must be due to changes produced in the metal by the current passed through it, but is unable to offer an explanation of the mechanism which produces such a result. [See Abstracts 503 and 1808 (1921).] T. C. H.

1655. *Strengthening of Photoelectric and Ionisation Currents by Means of the Electron Tube.* **G. du Prel.** (Ann. d. Physik, 70. 3. pp. 199–224, Feb. 15, 1923.)—The strengthening of the photoelectric current is dealt with first, and the experimental arrangement as used by Rosenberg is

described with the aid of a diagram, as is also the present experimental arrangement. It is found that by using a very good evacuated strengthening tube not only is its degree of action increased, but also the proportional scope between the unstrengthened and strengthened current is widened. Hand in hand with this goes a simplification of the experimental arrangement in the heating current circuit of the tube. With a special tube construction it is possible to raise the degree of strengthening of a single tube for very feeble photo or ionisation currents at least 10 million times. A. E. G.

1656. *Ionic Oscillations in the Striated Glow Discharge.* **E. V. Appleton** and **A. G. D. West.** (Phil. Mag. 45. pp. 879–881, May, 1923.)—In the course of experiments on the electrical properties of ionised gases for high-frequency electromotive forces, it was found that the ordinary striated glow discharge was more often than not a generator of electric waves. This indicates that the discharge is not steady as usually supposed, but pulsating in character. The presence of the waves has been detected by the ordinary wireless receiving devices, and most conveniently by an auto-heterodyne triode receiver, by means of which it has been found that the frequency of the oscillations is independent of the electrical constants of the circuit external to the discharge tube. The oscillations are therefore of a new type, being ionic in character and origin. Experimental details are very concisely and lucidly described. No detailed examination has been made of the dependence of frequency on gas-pressure and anode potential, but the frequency has been noted to increase usually with increase of pressure and of anode potential. H. H. Ho.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1657. *Resistivity of Vitreous Materials.* **L. L. Holladay.** (Frank. Inst. J. 195. pp. 229 235, Feb., 1923.)—Measurements were made on a number of glass tubes at temperatures up to about 530° C. From these it is concluded that the formula governing resistivity is

$$\text{Log}_\epsilon R - x \log_\epsilon T = Q/T - \log_\epsilon P$$

The equation for R may therefore be written $R = \frac{T^x}{P} \epsilon^{Q/T}$. W. R. C.

1658. *Development of Conductivity by the Heat Emission of Phosphores.* **E. Rupp.** (Ann. d. Physik. 70. 5. pp. 391 404, March 8, 1923).—The researches of Lenard and Saeland [see Abstract 873 (1909)] and of Gudden and Pohl [Abstract 914 (1921)] on conductivity changes during the activation of phosphores by light, occasion the assumption that the light emission from the active phosphorescence centres might be bound up with conductivity changes also. In the present investigation it is found that, in the emission of phosphorescent light by thermal effects, a conductivity increase occurs with all phosphores, and its dependence upon the imposed field and on the light emission has been sought. The measurements have been carried out in a simple form of apparatus which is very fully described, data being included for the phosphores, CaBiα, SrBi, BaBi, CaCu, SrCu, ZnCu, ZnMn, CaOBi, and CaOCu. The increase of conductivity is found to be proportional to the light sum of the phosphores,

and for similar basic material the latter is independent of the spectral position of the bands. The cause of the conductivity increase has been traced to the thermal emission produced by returning electrons. On this proportionality of the conductivity change with the photo-electrically measured light sum, a new method has been based which has been applied practically to the spectral emission distribution of CaBiα and ZnCuα. Lenard's theory of thermal excess by a storing of activity in the phosphore appears now capable of being put to experimental proof. H. H. Ho.

1659. *Resistance of a Hot Wire in an Alternating Air Current.* **R. C. Richards.** (Phil. Mag. 45. pp. 926–934, May, 1923.)—A standard hot-wire microphone was mounted on the prong of an electrically excited tuning fork whose amplitude was kept at a constant value. As the fork vibrated the hot wire was thus carried to and fro in an harmonic motion, and was therefore subjected to an harmonic draught. After describing the experimental arrangements, the author classifies the various draughts with respect to their frequencies into three groups: (*a*) Low frequency draughts (2 or 3 per sec.); (*b*) medium frequency draughts (50–60 per sec.); (*c*) high frequency draughts (120 and over per sec.), and deals with the two resistance changes (α) steady drop and (β) oscillatory change, separately. The theory of these effects is explained mathematically. The two resistance changes produced by an alternating air current in a hot wire are examined separately and found to follow, at least approximately, some simple relations. T. C. H.

1660. *Effect of Pressure on the Electrical Resistance of Cobalt, Aluminium, Nickel, Uranium, and Cæsium.* **P. W. Bridgman.** (Am. Acad., Proc. 58. pp. 151–161, Jan., 1923.)—A supplement to the author's former work in which the effect of pressure on the electrical resistance of 39 elements has been given. The first three of the above metals have been investigated previously, but the samples studied here are of considerably greater purity. The technique of the measurements is that described in the earlier papers. The pressure coefficients found for these purer samples are of the order 10 % higher than the previous values and the temperature coefficient of resistance increases with increasing purity. It is also found that the apparent anomaly which existed as regards the temperature coefficient for aluminium disappears. Hitherto the values published for examples of increasing purity have, unlike those for other metals, become smaller. The purest of these samples had about 0·1 % impurity. Beyond 0·1 % this trend is reversed, and at sufficiently high purities the temperature coefficient increases with increasing purity, and is higher than that for the impurer specimens. The specimen examined here contained 99·976 % Al. The uranium is in the form of rolled sheet 0·05 cm. thick, 0·7 cm. wide, 4·5 cm. long. Flaws in the metal do not affect the compressibility measurements, but would have interfered with the resistance determinations; hence these were made from a small homogeneous strip 0·97 cm. wide, 2·2 cm. long, which had to be cut with a steel disc charged with diamond powder. Leads cannot be soldered to the metal; they are attached by a special spring clamp to fine grooves filed in the end of the strip. This, with the small resistance, prevents high accuracy, but in any case the purity of the specimen is probably low (temperature coefficient between 0° and 100° C. is 0·0023). The resistance is found to decrease with pressure, as for most metals. The

sign of the pressure coefficient is important owing to the position of Ur at the end of the periodic table. The average pressure coefficient over the range 0 to 12,000 kg./cm.^{2} is $-4{\cdot}36 \times 10^{-6}$ per unit resistance at 30° C. and atmospheric pressure per kg./cm.^{2}. The specific resistance, apparently hitherto unrecorded, is $76{\cdot}0 \times 10^{-6}$, which is high for a metal and of the order for that of liquid Hg or Bi. The results for cæsium are preliminary, as final success in the preparation and manipulation of pure cæsium has not yet been attained. It is established that cæsium has a new modification at high pressures, that the transition point is sharp, and that the transition pressure varies with temperature. The probable transition pressure at 0° C. is 1980 kg./cm.^{2}, at 17° C. 3260 kg./cm.^{2}; the transition curve is of the normal type, rising to higher temperatures at the higher pressures, and the phase stable at the higher temperatures has the greater volume. It should be possible to find the new modification at atmospheric pressure at some temperature below 0° C., linear extrapolation gives − 26° C. The electrical properties of the high pressure modification are abnormal in that the resistance increases with pressure and at a continually increasing rate. This is similar to the properties of Bi, Sb, Ca, Li, Sr, the five other abnormal metals. At the transition point there is a discontinuity in resistance in the normal direction the high-pressure phase, the phase with the smaller volume having the smaller resistance. T. H.

1661. *Calculation of High-Frequency Inductances.* **F. B. Pidduck.** (Phil. Mag. 45. pp. 783-786, April, 1923.)—The inductance calculated is that of a ring of any cross-section at very high frequency. E. M.

1662. *Reversible Inductivity of Rochelle Salt Crystals.* **J. G. Frayne.** (Phys. Rev. 21. pp. 348-359, March, 1923.)—By analogy with what Gans [Abstract 1845 (1908)] has called the reversible permeability of iron, the reversible inductivity k_r of Rochelle salt crystals is defined as the limit of the ratio of the change of induction to the change of electric field in the dielectric as these approach zero. A study was made of the *variation of k_r with the frequency of the alternating field* for frequencies up to 4×10^7 cycles for the crystal at 0° C. Above the natural periods of vibration of the plate, 60,000 and 156,000 cycles, k_r was constant at 70, while below them it was constant at about 112 to 8000 cycles, and then began decreasing. The lower frequency values are affected by piezo-electric effects due to mechanical vibration in certain ranges and by polarisation effects which increase as the frequency decreases; hence the high-frequency values have a simpler physical significance. *Variation with temperature.*—Curves obtained for frequencies of 10^6, 50,000 (near resonance), and 8000 cycles all show maxima for about − 16° and 24° C. The minimum at about 6° may be associated with the maximum piezo-effect, which occurs in this range. *Hysteresis.*—The above results are for an applied electric field of zero. As the field is increased, k_r reaches a maximum, then a minimum, and then increases to infinity as conduction begins for 2700 or 3000 volts per cm., depending on the direction. *Natural polarisation* may be estimated from the asymmetry of the hysteresis loop. Two samples gave 125 and 175 volts per cm. A comparison of the temperature curves for three samples cut from the same crystal shows marked differences, which indicate that the natural polarisation is far from uniform even in the same crystal. *Relation of k_r to high-frequency resistance.*—The

two properties vary in general in much the same way. *Mechanical vibrations of Rochelle salt condenser in an oscillating circuit.*—At the natural frequencies of the plate, abnormal values of k_r and of the resistance were found. In the case of the transverse resonance, the computed wave-length was four times the width of the plate. [See Abstract 1152 (1921).]

A. W.

1663. *A New A.C. Potentiometer.* **D. C. Gall.** (Electrician, 90. pp. 360–361, April 6, 1923.)—This paper describes an a.c. potentiometer which measures two rectangular components of the voltage under test. The instrument contains two elements; one, called the "in phase" potentiometer, is supplied with alternating current through a sensitive reflecting dynamometer, the readings of which can be standardised by means of d.c. and a standard cell. The second, or "quadrature," potentiometer is supplied with current in quadrature with the preceding; this element contains the primary of a mutual inductance, the secondary of which can be connected to the potential tappings of the first potentiometer through a vibration galvanometer. The mutual inductance is of such a value that, with the "in phase" potentiometer tappings at a chosen reading, balance can be secured by adjustment of the rheostat in the circuit of the "quadrature" potentiometer; the latter is thus indirectly checked against the dynamometer. With both elements standardised in this way a given voltage can be measured by connecting it to the instrument through a vibration galvanometer, the potential tappings of the two elements being joined in series therewith. By operation of the two elements and of phase-reversing switches, if necessary, balance can be secured between the unknown voltage and the sum of its two quadrature components tapped off the instrument. The apparatus is made by Messrs. Tinsley & Co. B. H.

1664. *Conditions for Optimum Sensitivity of a Ballistic Galvanometer on Closed Circuit.* **A. J. Staring.** (Arch. des Sciences, 5. pp. 97–109, March–April, 1923.)—In connection with certain magnetic researches the author has been led to investigate the means available for increasing to the optimum the sensitivity of a moving coil ballistic galvanometer working on closed circuit [see Abstract 756 (1923)]. Diesselhorst has studied the performance of the instrument, assuming all its dimensions to be given, and has worked out the field strength which must be provided by its magnet to give the greatest sensitiveness. The author in the present article investigates, by a slightly simplified analytical solution of the differential equation, the independent effects of the various quantities (dimensions of moving coil, control torque, field strength, constants of the closed circuit, etc.) entering into the equations upon the optimum sensitivity. Details of design procedure to provide optimum sensitivity under stated experimental conditions are given. The paper concludes with the description of an instrument in which the moving coil system can be easily replaced by one suitable for the work in hand. Since the optimum sensitivity depends on the nature of the closed circuit, some means of adjusting the sensitiveness of the galvanometer to suit a circuit of given resistance must be provided. In the author's instrument an electromagnet is used for this purpose. In common with the observations of other workers it was found that, with the strong fields provided by the electromagnet (1200 gauss), the paramagnetic impurities in the moving

coil produced a marked increase in control and a loss of sensitiveness; this effect was overcome by the addition of small pieces of diamagnetic bismuth to the moving system. B. H.

1665. *Measurement of Transients.* **F. E. Terman.** (Am. I.E.E., J. 42. pp. 462–466, May, 1923.)—The transient crest meter here described was developed to investigate several problems in high-voltage transients. It consists of a gold-leaf electroscope in series with a rectifying valve, which allows the electroscope to charge, but prohibits discharge. By proper use of non-inductive resistance, inductance, and capacity, it is possible to make the applied voltage dependent upon the maximum peak, maximum slope, or maximum area of current and voltage waves, thus giving information regarding the character as well as the magnitude of the transient in question. For successful operation particular care must be taken to insulate the gold leaf. A block of sulphur serves very well, but even then special rectifying valves, in which the leads enter at opposite ends of the glass envelope, are necessary. Various applications of the device are described. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

1666. *Theory of Electric Wave Filters.* **L. J. Peters.** (Am. I.E.E., J. 42. pp. 445–462, May, 1923.)—This paper is essentially a treatment of certain types of coupled circuit networks by methods similar to those used in the discussion of long lines with distributed constants. The general theory is developed of the properties of identical circuits coupled so as to form a chain, and it is found that the equations giving the current and voltage of any circuit in the chain are identical in form with those giving the current and voltage at any point of a long line with distributed constants. The propagation constant, however, is a transcendental function of the circuit constants and of the frequency of the transmitted current. The nature of this function is such that sharp changes occur in the characteristic curve giving the attenuation constant as a function of the frequency. It is then shown how these sharp changes in the attenuation-frequency characteristic can be employed to build up filter networks. The general theory is next applied to the case of simple series circuits magnetically coupled so as to form a chain, and the paper concludes with a discussion of the problem of building up filters using sections of different types, numerical examples being given of the design of filters to meet certain pre-assigned requirements. A. W.

1667. *Eddy Currents in Solid Iron.* **E. Rosenberg.** (Elekt. Zeits. 44. pp. 513–518, May 31, 1923. Elek. u Maschinenbau, 41. pp. 317–325; Disc., 325–328 June 3, 1923. Paper read before the Elektrot. Verein, Vienna, Jan., 1923.) The author develops formulæ for the determination of eddy currents in solid iron, and describes a series of tests, undertaken for the purpose of ascertaining the value of the results as given by the formulæ. W. H. S.

1668. *Magnetisation in Weak Fields as a Function of Frequency.* **L. Page.** (Phys. Rev. 21. pp. 456–464, April, 1923.)—The attempt is made in this investigation to obtain a theoretical explanation of the known variation of the permeability of paramagnetic substances with

frequency, the usual one being that the inertia of the ultimate magnetic entity is so great that it is unable to follow sufficiently rapid oscillations of an impressed magnetic field. The magnetic properties of the atom are now supposed to be due to rings of electrons revolving about a nucleus, the field being assumed weak and damping neglected. The paramagnetic solid is first considered. Here a statistical distribution in the direction of the axes of the elementary magnets of which a magnetic solid is composed takes place as the result of collisions between molecules. In the time intervening between successive collisions the elementary magnets follow the impressed field, subject to such restraints as are imposed by the molecular field. From these considerations an expression for the permeability is deduced. The permeability is practically independent of frequency at first, then rises to a maximum for a frequency comparable with the number of collisions per unit time, decreases to a value less than one, and finally converges asymptotically to unity for an infinite frequency. The paramagnetic gas is next considered where the molecular field is absent and in consequence there is no maximum in the permeability. After decreasing to a value slightly less than one, the permeability approaches unity asymptotically. H. H. Ho.

1669. *Magneto-Thermic Effect according to Thermodynamics.* **J. P. Kuenen.** (K. Akad. Amsterdam, Proc. 25. 9 and 10. pp. 384–386, 1923. In English. Phys. Lab. Leiden, Comm. No. 47.)—Applying equations deduced from the second law of thermodynamics to the heat effect which accompanies a magnetic change, it is shown that $\frac{\partial T}{\partial H_\eta} = -\frac{T}{c_H}\frac{\partial \sigma}{\partial T_H}$, where H is the magnetic force, σ the magnetisation, and c_H the specific heat for constant field. This shows that the heat effect depends largely on $\frac{\partial \sigma}{\partial T_H}$, and thus explains the abnormally large effect around the Curie-point found by Weiss and Piccard. Other equations can be deduced similar to those stated by Weiss and Piccard without having recourse to Weiss' molecular-field hypothesis. In order to estimate the change in the specific heat at the Curie-point a molecular theory must be used. A. W. L.

1670. *Effective Permeability and Dielectric Constant of a Powder.* **G. Breit.** (K. Akad. Amsterdam, Proc. 25. 7 and 8. pp. 293–308, 1923. In English. Phys. Lab. Leiden, Comm. No. 46.)—In the case of gadolinium sulphate powder, the usual approximations for substances of small susceptibility do not suffice, and a correction has been applied by K. Onnes. The author finds the correction mathematically under certain assumptions, the density of packing of the powder and the constant of the material in the solid state being known. The treatment holds both for the magnetic and for the electrostatic problem. Within the first order terms the correction is the same for all the models considered, and may be expressed by the statement that the force on a sphere of the powder is equal to that which would be exerted on the material if it were moulded into a solid sphere. Different models give results differing in the second order terms in the demagnetising field. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1671. *Properties of Ozone.* **E. H. Riesenfeld.** (Zeits. Elektrochem. 29. pp. 119–121, March 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—A summary of still continued researches [Abstract 700 (1923)]. The solid ozone is black with a violet lustre. In determining the melting-point, the apparatus was first lowered into liquid hydrogen when it exploded at once; later, liquid hydrogen was poured on the ozone; the melting-point of ozone, — 250°, lies only a few degrees above the boiling-point of hydrogen. Pure ozone yields 1·54 cal. per litre, as much almost as electrolytic gas (1·73 cal.), and mixtures of oxygen with more than 12 % of ozone are explosive; by increasing the ozone concentration the explosion temperature can be raised at will. The determinations are difficult, but the equilibrium ozone-oxygen is so far the only case of the polymer of an element that can be studied in the solid, liquid, and gaseous phases. H. B.

1672. *Some Properties of Graphite.* **R. M. Burns** and **G. A. Hulett.** (Am. Chem. Soc., J. 45. pp. 572–578, March, 1923.)—The density of pure natural graphite—from Ceylon, Alabama, and Pennsylvania—is found by the liquid immersion method to be about 2·20 and that of Acheson graphite about 2·30. Carbon produced by explosion of graphitic acid has the density 2·215 and is, therefore, probably graphite. Samples of the graphites originally showed no "drift" or increase in weight with time after immersion in the liquid. The natural graphites, however, after being swelled or increased in volume by treatment with fuming nitric acid and heat, displayed remarkable drifts; pressure was used to hasten completion of the drift. The tendency to drift was largely destroyed by severe compression of the swelled material previous to the density determination. T. H. P.

1673. *Densities of Dilute Solutions of Potassium Salts and the Volume Changes Occurring on Solution.* **H. Hartley** and **W. H. Barrett.** (Chem. Soc., J. 123. pp. 398–401, Feb., 1923.)—Further measurements confirm the accuracy obtainable in determining the density of liquids by means of a pyknometer of about 25 c.c. capacity [Abstract 986 (1911)]. For solutions of potassium nitrate of less concentration than $\frac{N}{5}$, the densities within the limits of experimental error may be expressed by the equation: $d_4^{18} = 0{\cdot}998622 + 0{\cdot}00618c - 0{\cdot}000\,000\,65c^2$, where c is the concentration expressed as grams of the salt in 1000 grams of water. With the other potassium salts examined, the densities of the solutions cannot be represented by such a simple expression. In each case the process of solution is accompanied by contraction, and for dilute solutions the contraction of 1 gram-mol. of one and the same salt varies only slightly. T. H. P.

1674. *Theory of Solubility.* **J. H. Hildebrand.** (Phys. Rev. 21. pp. 46–52, Jan., 1923.)—The theory of solubility advocated by the author

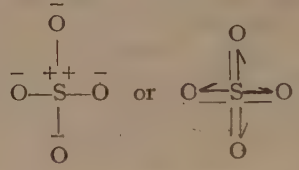
[Abstract 1868 (1921)] is summarised. Raoult's law will be obeyed by any liquid mixture in which the internal forces of attraction and repulsion do not change with changing composition of the mixture. When this condition holds, the solubility of a gas may be calculated approximately from its saturation pressure, and the solubility of a solid from its melting-point and heat of fusion. The above condition can exist only (*a*) when the components in the pure liquid state have the same internal pressures; (*b*) when the different molecules are relatively symmetrical or non-polar; (*c*) when the tendency to form chemical compounds is absent. Differences in either internal pressure or polarity alone produce approximately proportional positive deviations from Raoult's law and decreased solubilities. Tendencies towards chemical combination produce negative deviations and increased solubilities. Internal pressure is defined as $T(\partial P/\partial T)_v$; relative values may be deduced from other data, especially from the solubility relations themselves. Polarity is indicated by dielectric constant, etc., and depends on the symmetry and chemical constitution of the molecule. Chemical combinations are difficult to predict but, in general, occur most frequently between polar molecules, especially those which can be regarded as positive and negative, or basic and acidic, respectively.

In his criticism of the author's theory, Kunerth (Phys. Rev. **19**. p. 512, 1922) concludes that Raoult's law and internal pressures are practically useless as a basis for predicting the solubilities of gases. It is now pointed out that most of the solvents used by Kunerth are highly polar, and a table of gas solubilities in non-polar solvents is given. These solubilities cover a wide range and exhibit good agreement with the theory.

T. H. P.

1675. *The Electronic Theory of Valency. Part I. Intramolecular Ionisation.* **T. M. Lowry.** (Faraday Soc., Trans. 18. pp. 285–295; Disc., 295–301, Feb., 1923. Phil. Mag. 45. pp. 1105–1118, June, 1923.)—It is assumed that, in certain compounds, the atoms or radicles of which they are composed are ionised positively and negatively, and are held together by an electrovalency bond. The author speaks of such molecules as being "ionised" [they appear to be the same as the dipoles which figure largely in modern German physical theory]; and a number of gases, the molecules of which have a greater electrical moment than those which are neutral throughout, as shown by their dielectric constant and refractive index, are classed as having intramolecular ionisation, *e.g.* HCl, CH_3Cl, H_2O, NH_3, SO_2; while H_2, O_2, N_2, Cl_2, He, CO, CO_2, CS_2 are not ionised. Lewis represents carbon dioxide as $:\ddot{O}::C::\ddot{O}:$, and nitrous oxide which is isosteric with it as $:\ddot{O}::N::\dot{N}:$ [$:\dot{N}:$ would represent a neutral atom of nitrogen if the dots represent the valency electrons, so that the central $:\dot{N}:$ represents a positive ion, and the $:\ddot{N}:$ on the right a negative ion]; nitrous oxide can then be written $O{=}\overset{+}{N}{=}\overset{-}{N}$ or $O{=}N{\rightleftharpoons}N$, where the barb represents an electrovalency directed from the + to the − atom. The formulæ $:\ddot{O}:\overset{H}{\underset{H}{\ddot{O}}}:$ or $O{-}{-}O\begin{matrix}H\\H\end{matrix}$ or $O{\leftarrow}O\begin{matrix}H\\H\end{matrix}$ appear to represent the properties

of free hydrogen peroxide more accurately than the conventional formula, which shows two hydroxyl groups linked by a covalency HO . OH. Ozone is $:\dot{\underset{\cdot\cdot}{O}}:\dot{O}:\dot{O}:$ or $\overset{-}{O}-\overset{+}{O}=O$ or $O\leftarrow O=O$. [It appears that the oxygen ion on the left may be represented as $:\dot{\underset{\cdot\cdot}{O}}.$ with seven electrons in the outer shell, while the central positive ion is $\cdot\dot{\underset{\cdot\cdot}{O}}:$ with five.] The valency of one of the oxygen atoms is again increased by two units, one of covalency and one of electrovalency. A number of other substances are treated, and amongst them sulphuric acid, SO_4 being written



Stability in oxy-acids depends on the presence of a positive charge on the central atom of the ion. This also increases the strength of the acid. A maximum of stability and strength is reached in acids containing four atoms of oxygen round the central atom of the ion. *Discussion.*—**R. Robertson.** One of the most interesting parts of the paper, apart from the main contention, was the suggestion as regards the mechanism of acidity due to hydrogen. **A. O. Rankine.** Some measurements of the size of the SO_2 molecule suggested that its structure was not $O=\overset{+}{S}-\overset{-}{O}$, but $\begin{matrix} O \\ | \\ O \end{matrix}\!\!>S$. If nitrous oxide were written $\overset{-}{N}=\overset{+}{N}=\overset{-}{O}$ it would be polarised, but would be a neutral doublet, and would not display an abnormal dielectric constant. **R. Robertson.** The facts of organic chemistry demand that the true valency system must be an elastic one. The **author** would write nitrous oxide $N\equiv\overset{+}{N}-\overset{-}{O}$.

H. N. A.

1676. *Abnormal Osmosis through Collodion Membranes.* **G. Preuner** (with **O. Roder**). (Zeits. Elektrochem. 29. pp. 54–64, Feb. 1, 1923.)—The results of osmosis experiments with dilute solutions of potassium salts show that the osmosis reaches a maximum at concentrations lying between N/256 and N/512. When a collodion membrane separates an inner concentrated salt solution from an outer, more dilute one, the p.d. forcing the movable, charged liquid from the dilute to the concentrated solution and hence causing abnormal osmosis, depends on the diffusion of the salt. Since the diffusion p.d. between the two surfaces of the membrane depends on the fall of concentration within the membrane, the abnormal osmosis with fixed membranes must differ from that with rotating membranes. In the former case, when the solutions are stationary, the concentration at the surface of the membrane in the dilute solution is far greater than in other parts of this solution. As the concentration of the inner solution increases, the quotient of the

concentrations at the two walls increases to a maximum at a concentration for which, with an external e.m.f. and equal concentrations at the two sides of the membrane, the electro-osmosis and hence the electro-kinetic adsorption potential ζ attains a maximum value. This may be explained on the assumption that the coefficient of diffusion of the salt is a minimum at this concentration, this assumption being in accord with the fact that the diffusion p.dd. are much greater with than without membranes. The electrolyte behaves in the membrane as if the velocity of migration of the anion, v, were diminished by an amount increasing with the value of ζ.

Since, in the equation for the diffusion p.d., the values of $\frac{u-v}{u+v}$ and of the quotient of the concentrations assume maximum values at about the same concentration of the inner solution as ζ, the maxima of the diffusion p.d. of the abnormal osmosis and of electro-osmosis must be nearly the same.

With rotating membranes, the concentrations at the membrane surfaces differ little from the concentrations in the interior of the solutions, the fall of concentration outside of the membrane being limited to a thin adherent layer. The diffusion p.d. increases as the concentration of the inner solution increases to comparatively high values. For these reasons and also on account of the enhanced pure osmotic actions the transport of the liquid exhibits no maximum. The maximum of the abnormal osmosis with collodion membranes has, therefore, a different cause from that at collodion-gelatine membranes if, as Loeb states, it is conditioned by the increase of the diffusion p.d. and the diminution of the membrane charge as the concentration of the inner solution increases. T. H. P.

1677. *The Electro-Viscous Effect of Rubber-Benzene Sols.* **W. A. N. Eggink.** (Rec. des Trav. Chim. des Pays-Bas, 42. pp. 317–331, April 15, 1923.)—Measurements are made of the influence of the presence of different electrolytes on the viscosity of sols of rubber in benzene. Curves are plotted to show the relation of $(Ns + e)/Ne$ with the concentration of the electrolyte where $Ns + e$ is the viscosity of the sol containing electrolyte and Ne that of the benzene and electrolyte without the rubber. In most cases the curve falls asymptotically, converging towards a minimum value for viscosity for low concentrations of electrolyte. Of the substances added, the greatest effect is produced with hydrochloric acid, a concentration of 1·25 mill. mol. per litre, lowering the viscosity from 1·573 to 1·487. The other electrolytes investigated, in order of their effect, are sulphur dioxide, hydrogen sulphide, benzoic acid, and acetic acid, while ammonia causes a slight increase in viscosity. The phenomena observed show many analogies with those found for an aqueous agar sol, in which case it has been proved that the electrical properties of this typical emulsoid are the same as those of typical suspensoid sols. The theoretical deduction that the viscosity of a charged is larger than that of a discharged suspensoid, appears to be applicable to the emulsoid agar sol. The viscosity phenomena under the influence of added electrolytes appears to be of a capillary electrical origin and may be explained if the agar sol is considered as consisting of strongly hydrated, negatively charged particles distributed in the disperse medium; the negative electrical charge has been proved by cataphoresis experiments.

A calculation of the degree of dissociation of these electrolytes in benzene is made on the basis of a formula which has been found to hold approximately, namely, $D\sqrt[3]{v} = \text{constant}$, where D is the dielectric constant and v the volume or dilution for equal degrees of dissociation. Allowing further for the changing value of dissociation constant with dilution as determined by Walden, it is calculated that for a solution of 1 mill. mol. hydrochloric acid in 1 litre of benzene, α, the degrees of dissociation, $= 0{\cdot}32$. In the case of sulphur dioxide and ammonia, the amount of water dissolved in the benzene is in all cases largely in excess of that needed for the hydration.

The results indicate that in the benzene-rubber sol we are dealing with a negatively charged sol, which becomes charged on the addition of acids, since positive H-ions are then adsorbed, and charged on the addition of bases when negatively charged OH-ions are adsorbed. It is recommended that in order to overcome irregularities in measurements made hitherto on the viscosity of rubber sols for testing purposes, an excess of a strong electrolyte such as hydrochloric acid should be added when a correlative relationship should remain between the viscosity and different rubber properties. J. N. P.

1678. *Radio-Active Method of Studying Surface Changes in Finely-Distributed Precipitates.* **O. Hahn.** (Zeits. Elektrochem. 29. pp. 189–192, May 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—Slightly acid solutions of salts are mixed with a very small quantity of a solution of radiothorium and precipitated with ammonia or caustic soda; 10 to 15 mgr. of the precipitate, which will contain the radio-active substance, are spread on a small watch-glass which is kept for a few days in a screwed-down metallic box; its escaping emanation settles on a piece of aluminium foil over the watch-glass. The substance is tested in this way after being dried at ordinary temperature or at 105°, or calcined at moderate or at high temperature. It is presumed that the emanation will not act on the substance, and that its amount will depend upon the surface development; as the surface diminishes, and the crystals increase in size or the pores close up, the liberation of emanation will diminish. It was found by the author and O. Müller in experiments with salts of Be, Al, Ti, Fe, Zr, Ce, Th, etc., that high calcination stopped the liberation of emanation almost completely, and that oven drying at 105° C. reduced the amount of emanation escaping. This would be in accordance with J. A. Hedvall (Zeits. Anorg. Chem. 120. pp. 320–340, 1922), who found that the oxides of Fe, Co, Ni, Cu, Mg, though differing in colour, density, etc., when prepared by different methods, were all crystalline (not amorphous) and changed their surface character with heat, but did not represent different modifications, and gave identical X-ray spectra. The influence of various percentages of moisture was further studied by the author in desiccators (hygrostats). Dry oxides change more rapidly than moist oxides, the rates of change varying with the substance. The hydroxide $Fe(OH)_3$ changed least of all in a moist atmosphere; it aged in dry air, but recovered its large surface in moist air, and this change could be repeated many times; it is hence concluded that the change is due to the splitting-off of water and to shrinkage and closure of the pores, but not to rapid formation of crystals. Hydroxides of stronger heteropolar character, like $Ni(OH)_2$, age much more rapidly owing mainly to crystal

growth, and the surface changes are not reversible in moist and dry air. The author's determinations of the power of liberating emanation gives only relative figures; absolute values might be found by the method of Paneth and Vorwerk [Abstract 1934 (1922)]. H. B.

1679. *Relation of Hydrogen-Ion Concentration to the Flocculation of a Colloidal Clay.* **R. Bradfield.** (Am. Chem. Soc., J. 45. pp. 1243–1250, May, 1923.)—The flocculation of colloidal clays by different hydrogen-ion concentrations was studied. The clay was extracted from the subsoil of the Putnam silt loam by agitating the clay in a barrel churn with 5 parts of distilled water for 5 hours. The coarse particles were settled out for 10 days, the remainder removed by a Sharples supercentrifuge, making 32,500 revs. per minute. The solution was passed through the centrifuge a second time and a rather viscous, clear, dark amber-coloured liquid was obtained, in which no solid particles could be detected by an oil immersion objective. It contained 4·817 gram. oven-dried material per 100 c.c., and it showed no tendency to separate on long standing. This was diluted to a suitable concentration, 0·4 %, and mixed with the various flocculating agents in a specially designed vessel, so as to mix rapidly and the Sörensen values determined. The results showed that hydrochloric, sulphuric, phosphoric, and acetic acids flocculated colloidal clay at the same Sörensen value, but greater acidity was required with citric acid. F. J. B.

1680. *Determination of the Distribution of Size of Particles in Disperse Systems.* **T. Svedberg** and **H. Rinde.** (Am. Chem. Soc., J. 45. pp. 943–954, April, 1923.)—The principles for the determination of distribution of size of particles in a disperse system are discussed and an improved form of Odén's self-recording sedimentation balance, which permits recording quantities as small as 0·02 gram, with an accuracy of 0·0001 gram, are described and used in a series of determinations made upon mercury and gold sols. The increasing weight of sediment was compensated by means of an electric current passing through a coil acting on an iron cylinder and recorded on a recording milliameter. The compensation apparatus was worked automatically by means of a system of relays and a drum resistance rotated by a motor. From the relation between time and current the sedimentation curve can be found, and from that curve the distribution curve can be calculated. A method is described for determining the distribution of size of particles, depending on the variation of concentration with height in the sedimenting solution. A gold hydrosol was studied, and the concentration at different heights was measured by light absorption. F. J. B.

1681. *Tensile Tests of Alloys Undergoing Transformation.* **A. Portevin** and **F. le Chatelier.** (Comptes Rendus, 176. pp. 507–510, Feb. 19, 1923.)—In carrying out tensile tests on some aluminium-copper-manganese and aluminium-copper-magnesium-manganese alloys, it was observed that the load, instead of increasing in a regular manner, rose by a series of oscillations, whose amplitude was, in certain cases, as much as 4 % of the total load. At the same time Lüder's lines appeared on the surface of the metal, a series of lines appearing at each oscillation and being accompanied by a distinct noise. This phenomenon was only observed in metal which had recently been quenched, and was therefore under-

going the age-hardening transformation characteristic of these alloys. **Errata** (*ibid.* p. 620, Feb. 26, 1923). J. L. H.

1682. *Hardness and Hardening.* (Chem. and Met. Eng. 28. pp. 899–901, May 21, 1923.) *Strain and Fracture in Metals.* (*Ibid.* pp. 1026–1030, June 11, 1923.)—Summaries of lectures given by **W. Rosenhain** in America, reviewing modern views on hardness, slip, fracture, etc. The papers summarise and discuss these lectures, and are too concise to be abstracted. J. L. H.

1683. *Secondary Hardness of High-Speed Steel Heated after Quenching.* **G. Z. Nesselstraus.** (Rev. de Mét. 20 E. pp. 174–180, April, 1923.)—A series of chromium steels containing tungsten or cobalt, a tungsten steel, and two carbon steels were studied by means of thermal analysis, hardness measurement, and microscopic examination.

Thermal Analysis.—For the thermal analysis the specimens previously annealed were quenched at 1200° C. and differential thermal curves taken, the neutral body employed being copper. It was found that, while the second heating gave a normal curve, the first showed a vigorous exothermic reaction between 648° C. and 710° C. This transformation is very marked in the special steels, but can also be seen in the carbon steels, though in this case it is spread over a much larger temperature interval.

Hardness.—In the case of a steel containing 1·29 % C., 11·84 % Cr, and 4·28 % W., the maximum hardness was obtained by quenching (in oil) from a temperature slightly above 1000° C. With increasing quenching temperature the hardness fell, the fall being greatest on quenching from 1200° C. Annealing the 1200° C. quenched specimens above 500° C. produces a rise of hardness, which reaches a maximum on annealing at 650° C., after which higher temperatures cause softening. The specimen quenched at 1000° C., on the other hand, showed a fall in hardness which accelerates rapidly when the temperature passes 650° C. J. L. H.

1684. *Recent Progress in the Working and Applications of Alloys.* **L. Guillet.** (J. de Physique et le Radium, 4. pp. 89–114, March, 1923.)—An account is given of recent progress made in connection with iron, copper, aluminium, and magnesium alloys. Microphotographs of alloy steels, and also load extension, temperature, and cooling curves are included. Special reference is made to nickel-chromium, chromium, vanadium, and cobalt steels and their mechanical and thermal properties. Equilibrium diagrams are given for copper-tin, copper-zinc, and aluminium-copper alloys. Reference is made and data given for aluminium alloys with magnesium, copper, zinc, and silicon, and to binary and complex alloys of aluminium with these metals. The properties of the aluminium-magnesium-zinc alloys, known as "elektrons," are also dealt with. The equilibrium curves for nickel and chromium, lead-calcium, and lead-barium are discussed. A. W. J.

1685. *Metallographic Investigations on Tin Amalgams.* **F. Hauser.** (Zeits. f. Physik, 13. 1 and 2. pp. 1–6, 1923.)—The structure of a tin amalgam corresponding approximately with the formula HgSn is found to consist, like that of tin bronzes, of large granules which are built up of a crystalline

skeleton solidifying at a higher temperature and of a component still liquid at the ordinary temperature. The crystalline skeleton consists of acicular, tabular and granular particles, which are comparatively loosely united and are composed of very small crystalline granules. Centrifugation of the amalgam allows of the separation of the liquid component from the crystalline skeleton, and it is proposed to apply a centrifuge which can be heated to the study of the solidification of metals and alloys.

T. H. P.

1686. *Variations in Capacity Undergone by Hollow Steel Objects when Quenched.* **A. Portevin.** (Comptes Rendus, 176. pp. 897–899, March 26, 1923.)—The changes in volume of the cavity in 75-mm. steel shell caused by quenching is given in the table below, which shows that the method of quenching is of great importance.

Treatment.	Vol. change in C.C.
Quenched internally and externally simultaneously	+ 4·2 to + 5
Quenched externally only	+ 0·8
Quenched internally only	+ 6·5
Quenched internally 2 secs. in advance of external quench	+ 8·8

Repetition of the treatment causes continued growth, which appears to be due to a tendency to assume a spherical form.

J. L. H.

1687. *Photochemical Equivalence in Diluted Solutions.* **H. Grüss.** (Zeits. Elektrochem. 29. pp. 144–150, April 1, 1923.)—According to Noddack the photochemical reaction of chlorine on trichlorobromomethane yields bromine and carbon tetrachloride: $2CCl_3Br + Cl_2 + h\nu = 2CCl_4 + Br_2$, and decreases when more CCl_4 is added as diluent for the bromine compound [Abstract 403 (1922)]. The author tried other diluents and found the tetrachloride of silicon (and also of tin) alone suitable; all traces of moisture have to be excluded, since they would cause a turbidity due to silica. The arrangement was that of Noddack. Keeping the chlorine concentration constant and varying the concentrations of the bromine and silicon compounds, the author observed to his surprise that the yield of bromine per unit time increased as the dilution increased. He concluded that the $SiCl_4$ is not concerned with the reaction and that the bromine liberated is the new light-absorbing component. The rate of the reaction (as expressed above) is independent of the concentration of the trichlorobromomethane, at least down to dilution with 60 times the diluent $SiCl_4$ and 80 times the diluent CCl_4, when the latter is thoroughly purified. Pure CCl_4 is not an acceptor for chlorine, when radiated upon, and the contrary observations of Plotnikov and of Noddack are ascribed to traces of impurities. The primary reaction consists in the absorption of light by bromine; in the dark the energy acquired by the then activated Br_2' is transferred to the trichlorobromomethane or to the dissolved oxygen; the part played by oxygen (some of the solutions were saturated with air) is being further investigated. The reaction $O_2 + 2CCl_3Br = 2COCl_2 + Cl_2 + Br_2$ proceeds also in the dark at about 200° at a fair rate; it is hastened by the action of light on the bromine; this auto-sensibilisation is independent of the concentrations of the CCl_3Br and of the oxygen in solutions of CCl_4 and follows Einstein's law of equivalence, one molecule of bromine corresponding to one $h\nu$. The practical independence of the light re-

actions from the concentration of the active components further suggests that the higher-quantum Bohr state persists for at least 10^{-7} second. H. B.

1688. *Statistical Theory of Monomolecular Reactions.* **W. H. Rodebush.** (Am. Chem. Soc., J. 45. pp. 606–614, March, 1923.)—From the kinetic theory the following equation is derived for the rate of reaction of a unimolecular reaction: $\bar{N} = N\sqrt{RT/E_0\pi} \cdot e^{-E_0/RT}$, where $\bar{N}$ is the number of molecules possessing vibrational energy in excess of the critical amount, and the other terms have their usual significance. In the two cases where data are available, namely the vaporisation of mercury [Menzies, Abstract 239 (1920)] and the decomposition of nitrogen pentoxide (Daniels and Johnston, Am. Chem. Soc., J. 43. p. 53, 1921), the equation gives results which are probably as accurate as the data themselves. T. H. P.

1689. *Hydration of Acetic and Hydrochloric Acids and the Factors Determining the Activity of the Hydrogen Ion.* **W. C. M. Lewis, D. E. Merriman** and **T. Moran.** (Am. Chem. Soc., J. 45. pp. 702–712, March, 1923.)—The results are given of experimental determinations of the activity of the hydrogen ion (produced from acetic acid) in presence of various amounts of sucrose. The activity of the hydrogen ion may be accounted for completely by assuming that acetic acid is hydrated to the extent of 3 molecules of water per molecule of acid, and then identifying activity with the concentration of the hydrogen ion per unit of free water space in the sucrose solution. The change in the activity of hydrogen ion (produced from hydrochloric acid) in the presence of sucrose cannot be accounted for by a space correction alone. In this case the heat of dilution of the ion must be considered, and it is shown that, by combining the two above factors it is possible to account for 80–90 % of the observed activity; no definite conclusion is arrived at as to the causes of the excess activity observed; this excess might, however, be attributed to an increased ionisation of the acid, this being a modification of a suggestion made by Scatchard. The average degree of hydration of hydrogen chloride between 0·1 N and 1·2 N concentration has been calculated by an examination of the kinetics of the inversion of sucrose by this acid, employing the data of Fales and Morrell; the value found is approximately 7. T. H. P.

1690. *Electrometric Estimation of Zinc by means of Silver Nitrate.* **E. Müller.** (Zeits. Elektrochem. 29. pp. 49–53, Feb. 1, 1923.)—Zinc may be estimated by a method analogous to that used for nickel and cobalt. After addition of excess of potassium cyanide to the zinc solution, the excess of cyanide is determined by titration with N/10 silver nitrate solution, a silver wire being used as indicator electrode. Any silver present with the zinc may also be estimated by this process, which is, however, inapplicable to cadmium, lead, or copper. T. H. P.

1691. *Indicator Error in Titration.* **W. Böttger.** (Zeits. Elektrochem. 29. pp. 98–100, March 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—Preliminary communication on experiments by A. Richter on the elimination of the indicator error arising when carbon dioxide is evolved during titration analysis. It

is supposed that indicators like dimethylamino azobenzene, which is used in the determination of the concentration of the hydrogen ions, are insensitive to carbon dioxide; but there may be need for a positive and negative correction, which is much influenced by temperature fluctuations. H. B.

1692. *Electrometric Study of the Neutralisation of Phosphoric Acid by Calcium Hydroxide.* **G. L. Wendt** and **A. H. Clarke.** (Am. Chem. Soc., J. 45. pp. 881–887, April, 1923.)

1693. *Electrometric Titration of Molybdenum with a Titanous Salt.* **H. H. Willard** and **F. Fenwick.** (Am. Chem. Soc., J. 45. pp. 928–933, April, 1923.)

1694. *Electrometric Titration of Selenium in the Presence of Tellurium, Iron, and Copper.* **H. H. Willard** and **F. Fenwick.** (Am. Chem. Soc., J. 45. pp. 933–939, April, 1923.)

1695. *Corrosion by Electrolyte Concentration Cells.* **R. J. McKay.** (Am. Electrochem. Soc., Trans. 41. pp. 201–211; Disc., 211–215, 1922.)—Calculations of the e.m.f. generated on metal electrodes of the same metal by different concentrations of copper sulphate are given. Also, the results of determinations showing greatly accelerated corrosions of homogeneous metal in acid solution, due to differences in concentration of dissolved materials in the solution. AUTHOR.

1696. *Hydrogen-Chlorine Cell.* **F. Foerster.** (Zeits. Elektrochem. 29. pp. 64–79, Feb. 1, 1923.)—With the cell $H_2 \mid HCl \mid H_2$, composed of two parts, each containing a platinised electrode, and with currents of hydrogen and chlorine passed through the two parts respectively, currents of the order 10^{-2} ampere per sq. cm. are obtainable without excessive polarisation. The electromotive activity proceeds quantitatively with formation of hydrochloric acid which, in accordance with the difference between the transference numbers of $H^{\cdot}$ and Cl', accumulates to a far greater extent in the chlorine than in the hydrogen compartment. If other conditions remain constant, rise of temperature is accompanied by increase in the terminal p.d. of the cell, this being continued to a temperature which is the higher the greater the current taken from the cell. At temperatures above 80°, however, this p.d. falls when the current is large, the diminution in concentration of the gases diminishing the velocity of their electromotive reactions more strongly than this is raised by the rise in temperature. The velocity of the electromotive reaction of the chlorine is very high and independent of the character of the electrodes, whilst with the hydrogen a high velocity of reaction is attained only with the help of the catalytic action of platinum, and even then marked polarisation occurs with higher currents. The electromotive activity of the hydrogen is restricted mainly to the thin layer of the electrolyte covering the surface of the electrode protruding into the gas space. In view of the necessity of using platinised hydrogen electrodes and of keeping a rapid current of hydrogen passing through the cell, the preparation of hydrochloric acid from its constituent elements in a galvanic cell, with simultaneous generation of electrical energy, is impracticable commercially. The combustion of hydrogen in chlorine is a simpler and more suitable process. T. H. P.

1697. *Cataphoresis of Proteins.* **T. Svedberg** and **E. R. Jette.** (Am. Chem. Soc., J. 45. pp. 945–957, April, 1923.)—A method of determining the rate of migration of the protein particle under the influence of an electric field is described. The method depends on the fact that under illumination by ultra-violet light, proteins fluoresce. The fluorescence may be photographed and the positions of the boundaries of the protein sol measured on the photographic plate. Photographs are given showing the effect of changing the hydrogen ion concentration of a 0·3 % egg-albumen sol on its rate of migration. F. J. B.

1698. *Deformation of Gels by the Action of an Electric Current.* **F. Michaud.** (Comptes Rendus, 176. pp. 1217–1219, April 30, 1923.)—Gels of various types, when placed between two electrodes and submitted to an electric current, contract at the anode and swell at the kathode. The deformation appears to be related to electrical endosmose whereby water incorporated in the gel is conveyed in the direction of the current, *i.e.* leaving the anode and collecting at the kathode. Electrical endosmose is also obtained with a septum of gelatin. A plate of agar gel suspended in water and attached to an arm of a balance contracts when the gum is connected as anode and expands when joined as kathode. This effect is still better shown by coating a metal wire with a thin film of the gum.

The observed phenomena support the view that gels are formed of a network of fine channels filled with liquid and that an electrical double layer is formed on the partitions. If the channels have a smaller diameter than the thickness of the electrical double layer, only the (negative) charges adhering to the partitions can penetrate into the interior of the gel while the positive remains outside. This effect explains the property of swelling and the above deformation phenomena on applying a p.d. On altering the concentration of the $H^{\cdot}$ ions, the charges are modified or even reversed in accordance with the known influence of acids and bases on the swelling of gelatin. Agar gel is found to contract in an acid and swell in an alkaline medium, but the inversion point occurs at a high acid concentration instead of when nearly neutral as with gelatin. The electrical properties observed are considered to have a biological bearing in connection with muscular contraction. J. N. P.

1699. *A Plea for Rational Interpretation of Hydrogen Ion Measurements.* **W. C. Moore.** (Am. Electrochem. Soc., Trans. 41. pp. 137–145; Disc., 145–149, 1922.)—It is pointed out that, in many biological systems, hydrogen ion regions are of more importance than actual hydrogen ion concentrations. Finally, a plea is made to express hydrogen ion concentrations in any one set of measurements in terms of a common denominator instead of as "*p*H" values, which for chemical work sometimes seem inconvenient. AUTHOR.

1700. *Electrolytic Dissociation of Water in Salt Solutions. Viscosity Determinations.* **E. Linde.** (Zeits. Elektrochem. 29. pp. 163–168, April 1, 1923.)—To determine the dissociation of water in concentrated solutions, Palmaer and Melander (*ibid.* 21. p. 418, 1915) measured the e.m.f. of two hydrogen electrodes in concentration cells either of LiCl or of $CaCl_2$. If the concentrated and the diluted salt solutions had the same viscosity, the liquid potentials should vanish when the liquids had the same conductivity though different concentration. Palmaer

recognised the need of a viscosity correction which the author applies having, with the aid of an Ostwald viscosimeter, determined the viscosity of solutions of these two salts at higher concentrations than Hosking [Abstract 1754 (1904)] and Sachanov [Abstract 2011 (1913)] had investigated. The product of conductivity and viscosity (expressed as a function of the concentration) is found to increase steadily with increasing concentration ; so far as they go, the previous viscosity values are confirmed. In the case of LiCl the viscosity curve is rectilinear up to concentrations of 30 % and more, whilst the conductivity maximum is already reached near 22 %. It proved impossible to find two solutions of the same salt having different concentrations but the same degree of ionisation. But the viscosity corrections required are not large. Applying these corrections the author calculates the hydrogen-ion concentration for the two salt solutions by Nernst's formula. In both salts this $H^{\cdot}$ concentration becomes very high at high salt-ion concentration. H. B.

1701. *Electrolytic Preparation of Alkali Chlorate with Anodes of Magnetite.* **G. Grube** and **F. Pfunder.** (Zeits. Elektrochem. 29. pp. 150–163, April 1, 1923.)—Technically the anodes of magnetite (ferrous-ferric iron oxide) of the Griesheim-Elektron Co. are used in the place of the original platinum anodes. With these, chlorate yields of over 80 % are claimed to be realised ; but Foerster and Young, and E. Müller and Renschler obtained better yields with anodes of platinum and also graphite. The author used Griesheim-Elektron anodes, cylinders of 1·5-cm. diameter, in lengths of 12 cm. They were slightly attacked, especially at high current-densities ; at the recommended density, however, the dissolved iron hydroxide remained colloidal, and the electrode loss in 1000 hours was insignificant. The best chlorate yields of 85 to 90 % are obtained at an anodic current-density of 0·01 to 0·015 amp./sq. cm. and 60 to 70° C. in slightly acid saturated solution of sodium chloride, kept acid by occasional addition of hydrochloric acid. In neutral solution the yield is poorer than with platinum anodes, because OH' ions are discharged in addition to chlorine and chlorate, and the hypochlorous acid is catalytically decomposed by the iron oxides. The electrolysis of alkaline hypochlorite and of the free hypochlorous acid with magnetite electrodes shows that the mechanism of the chlorate formation is the same as with platinum anodes. In neutral cold solution the chief reaction is the anodic formation of chlorate according to $6ClO' + 3H_2O + 6\oplus \longrightarrow 6H^{\cdot} + 2ClO_3' + 4Cl' + 3O$, whilst in acid warm solution the chlorate is mainly formed secondarily according to

$$2HClO + NaClO \longrightarrow NaClO_3 + 2HCl.$$

H. B.

1702. *Electrolytic Alkali Permanganate from Manganese by Superposed Alternating Currents.* **G. Grube** and **H. Metzger.** (Zeits. Elektrochem. 29. pp. 100–105, March 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—Anodically polarised electrolytic manganese dissolves in caustic soda with valencies 2, 3, 6, 7. The 2, 3 valencies are only observed under special conditions [Abstract 1495 (1923)] ; as a rule, manganate and permanganate are formed, the latter in diluted cold solutions. Technically, permanganate is generally prepared by fusing the dioxide with potash and electrolytically oxidising the

manganate, and not by the direct electrolysis of manganese or ferro-manganese (Lorenz). The latter process has, however, been taken up in America during the war [Henke and Brown, Abstract 965 (1921)] with ferro-manganese or impure manganese. The authors use pure electrolytic manganese. At ordinary temperature the yield of permanganate, with direct current in potassium carbonate, is low (29 % max.). When a.c. is superposed on the anode, the yield is little improved (up to 32 %) and only with medium a.c. densities, whilst high densities actually lower the yield. The favourable effect of the a.c. is due to its counteracting the depletion of alkali at the anode ; at higher a.c. density the depolarisation and the formation of manganate predominate. There is always liberation of oxygen. H. B.

1703. *Electrolytic Preparation of Ortho-Amidophenol.* **O. W. Brown** and **J. C. Warner.** (Am. Electrochem. Soc., Trans. 41. pp. 225–238, 1922.)—A brief summary is given of the published work on the electrolytic preparation of ortho-amidophenol. All reductions of ortho-nitrophenol to ortho-amidophenol were carried out in caustic soda solutions and at a copper gauze kathode. Tabulated results of experiments are given which show the effect of current-density, concentration of caustic soda and ortho-nitrophenol in the kathode liquor, and of temperature at different current-densities on current efficiency and material yield. The tabulated results are also expressed graphically by curves. The quantity of amine produced was determined by a method involving diazotisation with standard sodium nitrite. AUTHORS.

1704. *Electrochemical Preparation of Tin Hydride.* **F. Paneth.** (Zeits. Elektrochem. 29. pp. 97–98, March 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—The yields of chemical methods [Abstract 1866 (1921)] being very poor, the author tried other methods. The glow discharge between tin electrodes in diluted hydrogen gave a little tin hydride, but only in the presence of some hydrocarbon, which made the preparation of a pure product impossible. Discharges in liquid hydrogen, with wire electrodes dipping into the liquid, were tried with lead and antimony ; no hydride was formed, though F. Fischer had prepared nitrides in this way (in liquid nitrogen). Generation of hydrogen at kathodes of the metal (Ernyei's method, 1900) failed with tin. When spark discharges were superposed on the continuous current, some tin hydride was formed, but the yield was very low. More satisfactory is electrolysis of a tin sulphate solution with electrodes of lead (or mercury) at which hydrogen is liberated under supertension ; the hydrogen generated contains 10 % of tin hydride. H. B.

1705. *Electrolysis of Acetic Acid by Commutated Direct Currents. Optical Sensibilisation.* **E. Baur.** (Zeits. Elektrochem. 29. pp. 105–110, March 1, 1923. Paper read before the Deut. Bunsen-Gesell., Leipzig, Sept., 1922.)—The investigation is to support the author's theory of optical sensibilisation. Optically-sensibilised substances undergo photolysis when radiated upon in the presence of sensibilisators ; the latter need not suffer any permanent chemical change, but are only modified into a Bohr state which contains the additional quantum $h\nu$ of absorbed energy. Photolysis and electrolysis are closely interrelated ; both are oxidation-reduction processes [see Abstract 233 (1922)], the e.m.f. coming

into play corresponding to the $h\nu$. In the photolysis of acetic acid into ($CH_4 + CO_2$), the first products would be the same as in the electrolysis and they would then react upon one another. These first products are the ions of acetate and hydrogen ; both change at once, the products being ethane, carbon dioxide and hydrogen, and even strong stirring would not carry the one product over to the other electrode so as to cause interreaction. But this might be effected by rapid alternating current pulses, provided some one of the products have a sufficiently long life. The question of the possible intermediate products has been much contested since Kolbe first electrolysed acetates in 1849. The author finds that methane is actually formed by commutated direct-current pulses, and he assumes that acetyl peroxide is an intermediate product capable of existing for a small fraction of a second. Alternating-current electrolysis is not suitable, because the liberation of the anodic ion requires a certain supertension and it takes time to render the anode passive. The commutator arrangement is that which Leblanc used in his passivity research. In photolysis the anode and kathode reactions proceed simultaneously and within molecular ranges. It is concluded that electrolysis with smooth platinum electrodes of potassium acetate, mixed with acetic acid, by current pulses (20 to 70 per second apparently), yields hydrogen, carbon dioxide, and hydrocarbons, *viz.* methane and ethane in about equal proportions. Reference is also made to the electrolysis of oxalic acid and to the researches by the author and A. Rebmann on the photolysis of water, carbon, dioxide, and uranyl oxalate (Helvet. Chim. Acta, 4. p. 256, 1921 ; 5. pp. 221 and 828, 1922). H. B.

1706. *Electrolytic Oxidation of Benzene to Quinone, and the Reduction of Quinone to Hydroquinone.* **A. Seyewetz** and **G. Miodon.** (Soc. chim. de France, Bull. 33. pp. 449–458, April, 1923.)—An investigation is made of the most favourable conditions for the oxidation of benzene to quinone, and for the reduction of quinone to hydroquinone by kathodic hydrogen. The anode used consists in all cases of a cylinder of sheet lead perforated with holes and surrounded by a porous diaphragm cell. An important catalytic action is exerted by the layer of lead peroxide which forms on the surface of the anode at the expense of sulphate dissolved in the electrolyte. It is advantageous to submit the electrodes to occasional reversals of current in order to form a spongy surface. The current density can be varied within the limits between 3 and 5 amps. per dcm.^{2} and 5 to 50 amps. per litre of emulsion. The most suitable electrolyte is an emulsion of benzene in 25 % sulphuric acid solution together with 33 % of acetic acid. In presence of lead peroxide the current yield of quinone under the most favourable conditions amounted to 65 % while, in absence of lead peroxide, this did not exceed 25 %. A diminution or increase of the sulphuric acid beyond this proportion causes a rapid fall in the yield. The dispersion of the benzene is best effected by projecting the electrolyte by means of a helical stirrer against the anode surface. The use of protective colloids to stabilise the emulsion causes a fall in efficiency. The temperature is one of the most important factors and allows the nature and proportion of the different products of oxidation to be varied. A temperature of 24–35° C. gives the highest yield of quinone in the case of the electrolyte mentioned, while, at higher temperatures, the formation of oxalic acid increases.

The substances tried as catalysts include, in the order of their activity, compounds of Pb, Ag, V, Ce, Mn, and Fe. The yield of quinone falls rapidly with its increasing content in the benzene, while the formation of oxalic acid increases. Though the solubility of quinone amounts to 5 % at 20° C., the fall in efficiency does not permit the concentration to be taken beyond 1 %, at which stage it is necessary to extract the quinone formed.

A continuous process is devised in which quinone formed at the anode is allowed to circulate to the kathode, where it is reduced to hydroquinone which is insoluble in benzene and is thus readily removed from solution in the electrolyte. This reduction is practically quantitative when the benzene solution is emulsified in an electrolyte identical with that utilised for the oxidation and maintained at a temperature of 40° C. The presence of 1 % vanadic acid catalyses the reduction and enables it to proceed at a lower temperature. J. N. P.

1707. *Luminescence at Tungsten Anodes.* **M. Katalinic.** (Zeits. f. Physik, 14. 1. pp. 14–18, 1923.)—An investigation is made of a resistance phenomenon shown by tungsten when employed as anode during electrolysis with sulphuric acid solutions. The acid is employed in varying concentrations, with potential differences of from 2 to 130 volts and with varying current densities. The anode consists of a tungsten wire 0·7 to 0·8 mm. thick, fastened at the end in a glass tube and projecting beyond for 1 to 2 cm. in the electrolyte. The kathode consists of broad plates of some other metal. With a p.d. of 2 volts, a diminution of the current occurred after an interval of 5 to 15 mins., while with 60 volts, the current was almost completely arrested after 1·5 sec. The length of this interval increased with increasing length of the exposed anode wire. At lower voltages, the resistance is found to be due to the formation of the oxides WO_2 and W_2O_5, while at higher voltages the yellow oxide WO_3 is mainly formed. The formation of the higher oxide is accompanied by characteristic luminescence at the surface of the anode. With a potential of 60 volts an intermittent faint green glimmering is observed to surround the anode and at higher voltages the luminescence becomes more stationary and permanent. The phenomenon is also noticeable with alternating current when, by means of a rotating mirror, it is seen that the effect is only obtained during one phase of the cycle. With an electrolyte of nitric acid a sudden increase in potential is accompanied by a sudden increase in luminosity which gradually diminishes to its former intensity. With copper sulphate, effects similar to those given with sulphuric acid are obtained. The phenomena observed with sodium hydrate, sodium carbonate, and hydrochloric acid are also described. In some cases the luminescence is accompanied by a hissing noise. The luminescence which is attributed to the formation of WO_3 at a potential of 60 volts is similar to the effect observed with the pyrophoric oxide WO_2 when oxidised in air. An influence is exerted by the temperature produced at the surface of the anode through the Joule heat which, in some cases, causes particles of oxide to be detached, to form a suspension, and by exposing a fresh electrode surface leads to renewed attack and continuous luminescence. J. N. P.